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THE JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JANUARY 1913

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MONTHLY MEETINGS: BOSTON, JANUARY 22; NEW YORK, JANUARY 14; SPRING MEETING: BALTIMORE, MAY 20–23; MEETING IN GERMANY: JUNE 21–JULY 7

APPLICATIONS FOR THE SPRING BALLOT

are now being received. The date of closing this ballot will be February fifteen, and members therefore should lose no time in enlisting the interest of those whom they deem eligible for membership in the Society.

At the time the last ballot closed it was necessary to postpone action on over 150 applications, which were received so late that it was impossible to communicate with references before the final meeting of the Membership Committee.

Membership literature has been forwarded recently to a large number of persons at the suggestion of members who are now requested to follow up the matter personally and explain the need of filing applications at an early date. Such coöperation will do much to avoid disappointment on the part of those applying late and will greatly facilitate the work of the Committee.

Those acting as references are requested to return promptly the blanks which are sent them for endorsing candidates for membership, as even a short delay may cause an application to be held over to another meeting.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chairman.*

JANUARY 1913 VOL 35 No. 1

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

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THE JOURNAL is published monthly by The American Society of Mechanical Engineers.
Price, 25 cents a copy, or $2 a year, to members and affiliates of the Society; 35 cents a copy or $3 a year to all others. Postage to Canada, 50 cents additional; to foreign countries, $1 additional.
Entered as second-class matter, January 4, 1912, at the Postoffice, New York, N. Y., under the act of March 3, 1879.

COMING MEETINGS OF THE SOCIETY

January 14, *New York City*, Engineering Societies Building. Business meeting, followed by topical discussion on subject to be announced. Informal dinner, 6.15 p.m. Meet in Society's rooms.

January 22, *Boston, Mass.*, Joint meeting with Boston Society of Civil Engineers and Boston Section of American Institute of Electrical Engineers. Paper: New Water Supply System for New York City, J. Waldo Smith, chief engineer.

May 20–23, *Baltimore, Md.*, Spring Meeting. Headquarters, Hotel Belvedere.

June 21–*July* 7, Joint Meeting with Verein deutscher Ingenieure, Leipzig and various industrial cities of Germany. See page 4 for further details.

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL 35 JANUARY 1913 NUMBER 1

THE SPRING MEETING

The members may look forward with anticipation to the coming Spring Meeting, to be held in Baltimore, May 20-23. This will be the first visit of the Society to this city and the cordiality of the invitation received from the members resident there, as well as the Engineers Club and the civic organizations, is evidenced by the fact that it was extended two years in advance of the date for the meeting.

The technical sessions have already been tentatively determined by the Committee on Meetings, and at a meeting of the Baltimore members, the Engineers Club and the civic organizations, held in Baltimore on December 19 and attended by the Secretary, the general scheme of social features was discussed. The Chairman of the Local Committee will be Layton F. Smith, past-president of the Baltimore Engineers Club.

Baltimore with its remarkable harbor and its nearness to Washington and Annapolis is a most attractive city in which to hold a convention, and the membership are assured of adequate and comfortable accommodations at the Hotel Belvedere, the headquarters selected. More than three hundred rooms are available and the hotel is most conveniently arranged in respect to meeting halls, accessibility, etc. As the date of the meeting comes within the height of the season in Baltimore, when the weather is ideal and the city is crowded with visitors, hotel accommodations should be reserved in advance and as early as possible, in order to insure against disappointment.

One of the excursions which will be included in the program laid out by the local committee will be a trip to Annapolis, one of the oldest cities in America, and hence of historical as well as pariotic interest. The trip will probably be made by boat, and the visitors will have an opportunity to see the grounds and buildings, on which fifteen million dollars have recently been expended, and to watch the midshipmen in various naval manoeuvres.

There will also be excursions to the hydroelectric plant at McCalls Ferry on the Susquehanna River, and to the various points of interest in Baltimore itself, such as the new sewerage disposal plant recently installed at an expense of twenty million dollars, the new system of municipal docks, as well as its principal industries, including sealing devices. canning and preserving, and tobacco.

MEETING IN GERMANY

Advice has been received from the Verein deutscher Ingenieure that since the meeting in Leipzig will occur during the summer vacation season when hotel accommodations will be strained to the utmost and because of the difficulty of conducting large groups through industrial establishments, the party which is to participate in the Leipzig meeting next summer must be limited to 200 members and 100 ladies. It is possible, however, that all who go may find accommodations. So far 176 members have signified their intention of attending the meeting.

The party will sail on June 10 on the Hamburg-American liner Victoria-Luise, arriving in Hamburg on Saturday, June 21. This vessel will accommodate 500 passengers, and the anticipation is that members and their friends will make up the entire passenger list. Through the courtesy of the steamship company, a discount of 5 per cent is being allowed on all bookings, provided such discount does not bring the net amount below the minimum; and in addition a discount of 20 per cent will be made on all who return by the Hamburg-American line before August 1, under similar conditions as regards minimum price. The total cost of the trip through Germany is estimated at $87 per adult, based upon a minimum number of 300.

The estimated cost of the entire trip is as follows:

New York to Hamburg, via Victoria-Luise	$97.50	(minimum)
Official trip through Germany	87.00	
Munich to Hamburg, 2d class ticket	10.90	
Return trip to New York (estimated)	95.00	(minimum)
	$290.40	

Applications will be registered in the order of their receipt at the headquarters of the Society. When the prescribed limit has been reached, any vacancies which may occur in the party will be filled in the order of receipt of subsequent requests.

The program as announced includes many features of interest. Upon arrival in Hamburg, the party will be formally received by the municipal authorities and will proceed by special train to Leipzig either the same or the following day. A visit will also be paid to the great shipyards in Hamburg. There will an informal gathering of the members of the party on Sunday evening, June 22, and on Monday morning, June 23, the meeting will formally open. The King of Saxony is expected to welcome the visitors and there will be two addresses, one by a representative of the German society and the other of the American organization, on some general subject, such as the history of engineering, the relation of capital and labor, and the effect on industry of technical education. Tuesday, the last day to be spent in Leipzig, will be devoted to technical papers and to various social events and participation in the patriotic gathering in commemoration of the one-hundredth anniversary of the battle of Leipzig.

The party will leave on Wednesday for a tour of industrial Germany, visiting the principal cities, and including a trip up the Rhine from Bonn to Rüdesheim. Independence Day will be celebrated at Frankfurt am Main under the auspices of the American embassy.

The final meeting will be held in Munich, July 7, in connection with the Museum of Technical Arts, of which Dr. von Miller is director.

CURRENT AFFAIRS OF THE SOCIETY

Following the suggestion made by Dr. Alex. C. Humphreys in his presidential address delivered at the Annual Meeting in New York, the Council has authorized the placing of the name of Alex. L. Holley to precede the list of past-presidents of the Society, with the title of chairman of the organization meeting. Mr. Holley may rightfully be regarded as a past officer and numbered among those who have done much to serve the Society.

CODE ETHICS

The attention of the membership is drawn to the report of the Code of Ethics Committee, appearing elsewhere in this issue. This preliminary code has been drafted by the committee with a view to promoting discussion from the membership, so that the final code may embody the views of as large a proportion of the members as possible and be so framed as to serve the best interests of the profession at large. The report will probably be discussed at the Spring Meeting of the Society in Baltimore.

DEPRECIATION AND OBSOLESCENCE

A committee of five has been appointed by the Council to confer with committees on Depreciation and Obsolescence appointed by sister societies, as to how to determine scientifically the rates for charge against depreciation and obsolescence.

STUDENT BRANCHES

A new student branch has been formed at Syracuse University, making the total number of these branches of the Society twenty-six.

At a meeting of the Yale Mechanical Engineers Club in New Haven on December 10, Prof. William Kent, who recently accepted appointment on the Committee on Student Branches, gave a talk on Engineering and Common Sense, in which he emphasized the importance of observation, absorption and concentration in all phases of education. Mr. C. H. Lambelet, who represented the Secretary, congratulated the branch on their work and invited the students to visit the rooms of the Society when in New York.

NATIONAL SOCIETY FOR PROMOTION OF INDUSTRIAL EDUCATION

The following Honorary Vice-Presidents were appointed by the Council to attend the convention of the National Society for the Promotion of Industrial Education, held in Philadelphia, December 5-7, 1912: Henry Hess, Charles R. Richards, F. W. Taylor, Morris L. Cooke and A. L. Williston.

Calvin W. Rice, *Secretary*

ADDITIONAL HOLDERS OF CERTIFICATES

The following names should be added to the list of the holders of Certificates of Indebtedness, published in The Journal for December:

J. D. Cox
R. S. Kent
C. E. Kinne
F. E. Kirby
Chas. Kirchhoff
E. S. Knisely
W. L. Lyall
C. D. Pettis

and for the name of Carl Schwartz should be read F. H. Schwarz.

THE ANNUAL MEETING

The thirty-third Annual Meeting of the Society, held in New York, December 3-6, 1912, was attended by 561 members and 356 guests. The meeting was noteworthy because of the unusually varied professional program which for the first time was largely under the direction of the sub-committees of the Committee on Meetings. There were nine professional sessions and the last, on Friday, was an all-day session devoted to the discussion of industrial management. The attendance at this session was large, indicating a sustained interest in the proceedings up to the end of the convention.

This year for the first time in many years the usual Thursday evening reception and dance was omitted and instead the award of the John Fritz Medal by the John Fritz Medal Board of Award was made on that evening. On the evening previous about 300 attended the dinner in honor of Professor John E. Sweet.

The various details of the convention which showed much forethought and care in their working out, were in charge of either standing or specially organized committees of the Society. The professional sessions were arranged by the Committee on Meetings, Dr. Charles E. Lucke, Chairman, and by the various sub-committees of this committee, covering various phases of mechanical engineering. The Committee on Meetings in New York, F. H. Colvin, Chairman, coöperated with the House Committee, Francis Blossom, Chairman, in caring for the entertainment features of the meetings, and members of these committees acted as chairmen of the sub-committees, Francis Blossom serving at the head of the Committee on President's Reception, H. R. Cobleigh of the Excursion Committee, and Roy V. Wright of the Acquaintanceship Committee.

A bureau of information was maintained in the foyer of the building during the convention which materially aided in the arrangements for excursions and other details of the meetings.

OPENING SESSION, TUESDAY EVENING

The meeting was opened on Tuesday evening in the auditorium of the Engineering Societies Building, with the president's annual address delivered by Dr. Alex. C. Humphreys, on The Present Opportunities and Consequent Responsibilities of the Engineer. Dr. Humphreys called to his aid the addresses made by presidents in the past, quoting such parts as were more particularly applicable to his purpose and concluding with his own ideas as to the education of the engineer and a review of the Society's activities during 1911-1912. Theodore Stebbins, Chairman of the Tellers of Election of Officers, was then called upon to make his report and the following results of the ballots cast were given: President, W. F. M. Goss; Vice-Presidents, James Hartness, I. E. Moultrop, H. G. Stott; Managers, W. B. Jackson, H. M. Leland, Alfred Noble; Treasurer, William H. Wiley. Past-Presidents Swasey, Smith and Meier were appointed to escort Dr. Goss to the platform and an introductory speech was made by Dr. Humphreys in which he offered President Goss the full and complete coöperation and services of the officers, committees and staff of the Society during the progress of his administration. Dr. Goss replied as follows:

> I am sure that you readily appreciate the embarrassment which one feels upon being introduced in such a manner as this and before such an audience. It seems commonplace for me to say to you and to all the members of The American Society of Mechanical Engineers that I appreciate the courtesy and generosity which has been shown me, but I feel that I should not be true to myself or fair to you if I did not say it. I understand the significance of this occasion. I deeply appreciate the tribute and I will endeavor so far as I am able to discharge the obligations which you, the members of the Society, have put upon me during the year for which you have elected me as your President. I thank you.

The audience then adjourned to the rooms of the Society on the eleventh floor where the members and their guests met the new officers. Music was rendered during the evening and a collation was served.

WEDNESDAY MORNING SESSION

The annual business meeting was held on Wednesday morning, December 4, in the auditorium, and was followed by professional sessions. The annual reports of the Council and Standing Committees were read and accepted, and the thanks of the Society tendered to those who had contributed to the work accomplished. The Tellers of Election to Membership reported 328 names acted upon favorably for membership in the Society.

A report was presented by the Committee on Increase of Membership, I. E. Moultrop, Chairman, who called attention to the efforts of the committee to coöperate with the Membership Committee, in an effort to raise the standard of admission.

The Committee on Constitution and By-Laws, Jesse M. Smith, Chairman, explained in detail the amendments to be voted on, and it was moved that these be referred to the membership for letter ballot.

Prof. F. R. Hutton, Honorary Secretary, reported for the committee appointed to write the history of the Society and asked for the coöperation of the membership in including in it details not generally known.

PROFESSIONAL SESSIONS

The professional sessions of this meeting were distinctive in that they were largely the result of the work of sub-committees of the Committee on Meetings. There were nine sessions in all, seven of which were either in charge of sub-committees or of the Gas Power Section, or were representative of the work of professional committees of the Society. Two technical reports presenting the " state of the art " were prepared by sub-committees, one upon the development of machine shop practice during the last decade written by Fred E. Rogers, chairman of the sub-committee on Machine Shop Practice, and the other upon industrial administration prepared by L. P. Alford, secretary of the sub-committee on Administration, with the advice and coöperation of the committee members. The latter report required for the discussion nearly the whole day on Friday. This, the last day of the meeting, when members have usually been departing for their homes, was this year the one at which the greatest interest was evidenced. The address of the chairman of the Gas Power Section reviewing European practice in this field was also of the same general character as the two reports mentioned.

On Wednesday afternoon the entire session was given to the reports of the special committees, among which were included the voluminous report of the Power Tests Committee which eventually will take the place of the several reports of the Society already issued on the testing of power plant apparatus.

At the time of the appointment of the first sub-committees of the Committee on Meetings it was hoped that their efforts would result in papers in different fields which would bear more or less directly upon other fields of work, even though not closely related to the former. This principle was emphasized at the textile session at which The Principles of Valuing Property by Henry K. Rowell proved of interest to members not identified with the textile industry. Another pleasing feature was an increasing interest in railroad subjects through the efforts of the Sub-Committee on Railroads.

The complete program is published herewith in which the papers and discussion are listed. The papers have been published in The Journal or will appear in this and later issues together with the discussion.

WEDNESDAY EVENING, DINNER TO PROFESSOR SWEET

One of the most delightful features of the meeting and one of the most unique events ever held in the Engineering Building, was the dinner tendered to Prof. John E. Sweet on the evening of December 4 by about 300 of "Professor Sweet's boys" and his friends in the Society, in appreciation of Professor Sweet's work in the organization of the Society. Dr. Alex. C. Humphreys made an address of welcome, and Captain Robert W. Hunt, Prof. Albert W. Smith, Dr. John A. Brashear, and Professor Sweet himself responded to toasts. The songs rendered by Mr. George A. Fleming proved an attractive addition to the program.

An excellent photogravure of Professor Sweet and also of the first Straight Line engine, which used to run the shops at Cornell University, were included in handsome menu cards given to each guest as a souvenir of the dinner, and the table was artistically decorated. Ambrose Swasey, Chairman, F. G. Tallman, Vice-Chairman, E. J. Armstrong, F. A. Halsey, Robert W. Hunt, E. D. Leavitt, William Kent, Charles R. Richards, Albert W. Smith, E. N. Trump, Worcester R. Warner and W. H. Wiley, acted as a committee in charge of the dinner, and were widely congratulated on the success of the evening.

Many telegrams and letters of good wishes were received by Professor Sweet from friends who were unable to participate in the occasion.

THURSDAY EVENING, JOHN FRITZ MEDAL AWARD

On Thursday evening, December 5, the John Fritz Medal for 1912 was publicly awarded at a meeting in the Engineering Societies Building, to Captain Robert Woolston Hunt, a past-president of the Society, for his contribution to the introduction of the Bessemer process in America.

The meeting was presided over by Prof. James F. Kemp, President of the American Institute of Mining Engineers, and grouped about Captain Hunt on the platform were the members of the John Fritz Medal Board of Award. Dr. John A. Brashear made the opening address, his subject being Early Reminiscences of the Steel Industry. E. Gybbon Spilsbury, in the absence of Onward Bates, President of the Board, then presented the medal to Captain Hunt, who responded with an account of his early participation in the steel industry.

After the ceremony the three founder societies, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, and The American Society of Mechanical Engineers, joined in tending a reception to Captain Hunt, to the three societies, and to the members of the American Society of Civil Engineers. A collation was served during the evening.

ENTERTAINMENT OF LADIES

A Ladies Committee, Mrs. Alex. C. Humphreys, Chairman, was again formed to welcome the visiting ladies, and served tea informally in the rooms of the Society on the afternoons of Wednesday and Thursday. Many of the members joined in taking the opportunity for social intercourse afforded by these pleasant occasions.

EXCURSIONS

On Wednesday afternoon two excursions were made: one to the Grand Central Terminal where, through the courtesy of George W. Kittridge, chief engineer of the New York Central & Hudson River R.R., the new construction under way was inspected under the guidance of Carl Schwartz. The main building covers an area on the street level 301 ft. wide and 722 ft. long; below the street level the station is 455 ft. wide and 745 ft. long. In this building which will be used for outgoing passengers only, are located the waiting rooms, concourses, baggage rooms, and other facilities of travel. The incoming station will be located on Vanderbilt Avenue and will have sub-surface connections with the main building.

The largest single item involved in constructing the terminal was the excavation, which was conducted under very unusual conditions. There could be no interference with the operation of trains, and the proximity of the steel construction and buildings occupied by human beings necessitated taking the greatest precautions. In many places the steel structure had to be erected within 3 or 4 ft. of the rock, the face of which was about 45 ft. high. The total excavation amounted to 3,094,750 cubic yards, about 2,000,000 of which was rock.

Next to the excavation, the steel construction is the largest single item. Over the suburban level, for the purpose of supporting the express-level tracks, covering an area of 38.1 acres, approximately 51,870 tons of steel are used. For viaducts and cross streets, aggregating 9,400 ft., about 1¾ miles, about 14,700 tons of steel are used; in the main building approximately 28,390 tons.

One of the unique features of the Grand Central Terminal is the use of ramps or inclined ways instead of stairways. The suburban business is separated from the through, and the incoming from the outgoing, so that the passengers on any one ramp all move in the same direction.

The track lay-out comprises over 33 miles and consists of two levels, the upper level having 42 tracks, 29 of which are adjacent to platforms, and the lower level having 25 tracks, 17 of which are adjacent to platforms. Both levels have loop tracks for the purpose of turning equipment. The rails at platforms are laid on creosoted timber set in solid concrete, for permanency and clean lines.

There are direct sub-surface connections with the Interborough, Hudson and Manhattan Tubes to Jersey City, Belmont Tunnel to Long Island, and the new Lexington Avenue Subway now under construction, thus establishing an intercommunication of travel between the station and the lines of local transit that will place every nook and corner of greater New York, Long Island and Jersey City in direct touch with it.

The second excursion was to the Waterside Station of the New York Edison Company. Through the efforts of John W. Lieb, Jr., third vice-president and associate general manager, stations Nos. 1 and 2 were again open to visitors from the Society. John H. Lawrence conducted the party.

On Thursday morning, through the kindness of William Williams, a party of 70 visited Ellis Island Immigration Station, M. F. Brophy acting as guide. On the return trip about 20 took advantage of Dr. C. H. Townsend's invitation to visit the Aquarium. In the afternoon one party went on an inspection trip over the Fourth Avenue Subway upon invitation of chief engineer Alfred Craven of the Public Service Commission. The subway is nominally a four-track structure, but the number of tracks is increased to as many as eight in places where undergrade connections are provided for future extensions. The Fulton Street portion comprises about 1000 ft. of extremely heavy and difficult work. There are six and eight tracks occupying two levels. Ground water was encountered before subgrade was reached and as the material is sand all adjacent buildings had to be underpinned in advance. The two elevated railroads crossing the cut are temporarily supported over it. The front portions of two theatres were shored up over the excavation without interfering with performances. At Flatbush Avenue the new structure was built by tunneling under the west end of the Atlantic Avenue station of the present subway. The tunneling methods were devised by Jacobs and Davies and were very successful. Frederick C. Noble conducted the party.

Still another party inspected the Bush Terminal in Brooklyn with its elaborate system for shipping and receiving freight and handling it to and from the various factories and warehouses at the terminal. Mr. W. C. Brinton acted as guide. On the same afternoon a trip was made to the Keller Mechanical Engraving Company by courtesy of W. H. Keller, general superintendent, and William A. Warman, Mem.Am.Soc.M.E., superintendent and designer. This concern manufactures automatic die-sinking and metal engraving machines and also has a department equipped with these machines where dies are made for the trade. It is the largest company of its kind in the world and has a force of designers, photographers, modelers, die sinkers, hardeners and finishers. Their foundry produces some of the finest bronze castings. Photography plays an important part in the economical production of the work, and Mr. Warman has devised a complete photographic department using paper negatives. The party was under the guidance of E. A. Suverkrop.

Mr. Suverkrop also conducted an excursion to the August Griffoul Brothers Company, Newark, N. J., on Friday morning. Mr. Griffoul and his two brothers learned the art of molding with Liard of Paris, France. Their work is gold, silver, bronze and iron casting of the highest class. In France they molded work from the hands of Rodin, and in this country they have cast work for all the eminent sculptors, St. Gaudens, James E. Fraser, etc. The trip to the Navy Yard by invitation of Capt. Albert Gleaves, also on Friday morning was especially interesting this year as the party was able to go over the Wyoming, the largest battleship in commission, then in drydock, and the New York, recently launched and now being equipped, which will be the largest battleship. Lieutenant-Commander W. B. Tardy acted as guide. In the afternoon, the courtesy of an inspection trip over the Pennsylvania Terminal and Sunnyside yards on Long Island was offered by F. L. Sheppard, general superintendent of the New Jersey Division. The party was conducted by William Couper. The new railway postoffice at the terminal was open for inspection through the kindness of Postmaster Edward M. Morgan.

About fifty made the excursion to the Woolworth Building on Saturday morning instead of on Thursday afternoon as scheduled. By the kindness of the architect, Cass Gilbert, the party was permitted to go to the top of the building and to inspect the entire power plant.

A number of additional excursions were provided that individuals might take at their own election. These included a view of the collection of firearms owned by A. W. Lawrence, inspection of the Port Morris Power Station, the Singer tower and power plant, Aqueduct work, Museum of Safety devices, and the following manufacturing plants: Crocker-Wheeler Company, Ampere, N. J.; Henry R. Worthington, Harrison, N. J.; Davis-Bournonville Company, Marion, N. J.; J. H. Williams Company, Brooklyn, N. Y.; Pond Machine Tool Company, Plainfield, N. J.; National Lead Company, Brooklyn, N. Y.; Goldschmidt Thermit Company, Jersey City, N. J.; Joseph Dixon Crucible Company, Jersey City, N. J.; E. W. Bliss Company, Brooklyn, N. Y.; De La Vergne Machine Company, New York.

RESOLUTIONS OF THANKS

During the professional session of Friday, the following resolutions of thanks were unanimously adopted:

Whereas the members and guests of The American Society of Mechanical Engineers at the Annual Meeting, December 1912, have again been accorded opportunities for participating in both the professional and social features of the meeting,

Be It Resolved that on behalf of the visiting members and guests the Secretary extend the thanks of the Society to the Committee on Meetings and to the sub-committees holding sessions, for the excellence of the professional program; to the Committee on Meetings of the Society in New York for their arrangements for the reception of guests; and to the House Committee and the Committee on President's Reception, the Excursion Committee, the Acquaintanceship Committee and the Ladies Committee, for the entertainment they provided; and

Be It Resolved further that the Secretary express the appreciation and thanks of the meeting to the various firms and institutions which extended their hospitality to the Society and permitted members to inspect these various buildings and points of interest.

PROGRAM

Tuesday Evening, December 3

President's Address: The Present Opportunities and Consequent Responsibilities of the Engineer, Alex. C. Humphreys.

Reports of Tellers of Election, of Officers and introduction of the President-Elect.

President's Reception in the rooms of the Society.

Wednesday Morning, December 4

Business meeting. Reports of the Council, tellers of election of membership, standing committees. Amendment to Constitution under C57, relating to election of members and membership grades. New business.

SIMULTANEOUS SESSIONS FOLLOWING BUSINESS MEETING

Power Plant Session

Dimensions of Boiler Chimneys for Crude Oil, C. R. Weymouth.

No discussion.

Tests of a 1000-H.P. 24 Tubes High B. & W. Boiler, B. N. Bump.

Discussed by W. D. Ennis, William Kent, J. H. Brown, D. S. Jacobus, C. B. Young.

Air in Surface Condensation, George A. Orrok.

Discussed by G. J. Foran, A. G. Christie, H. A. Everett.

Properties of Saturated and Superheated Ammonia, Wm. Earl Mosher.

No discussion.

PHYSICAL PROPERTIES OF ANHYDROUS AMMONIA, L. S. Marks and F. W. Loomis. (Presented through the courtesy of The American Society of Refrigerating Engineers.)

No discussion.

EXPERIMENTS WITH NORTH DAKOTA LIGNITE IN A STEAM POWER PLANT AND A GAS PRODUCER, Calvin H. Crouch.

No discussion.

THE BALTIMORE SEWERAGE PUMP VALVE, A. F. Nagle.

No discussion.

TEXTILE SESSION

THE PRINCIPLES OF VALUING PROPERTY, Henry K. Rowell.

Discussed by Charles Fitch, C. J. H. Woodbury, C. T. Main, C. T. Plunkett.

THE POWER PLANTS OF TEXTILE MILLS, John A. Stevens.

Discussed by Charles Fitch, C. T. Main, C. T. Plunkett, C. C. Thomas, C. J. H. Woodbury, W. H. Cary, C. W. Burleigh.

GAS POWER SECTION

Chairman's Address: RECENT DEVELOPMENT OF GAS POWER IN EUROPE, H. J. Freyn.

Discussed by Wm. T. Magruder, D. G. Baker, Mr. Chubb, W. R. Haynie.

HEAVY OIL FOR USE IN INTERNAL-COMBUSTION ENGINES, Irving C. Allen.

Wednesday Afternoon

Reports of special committees, including Power Tests, Hoisting and Conveying, Standard Cross-Section Symbols, Involute Gears, Standardization of Catalogues, Flanges, Pipe Threads.

RECEPTION

Reception to members and guests of the Society, given by the Ladies' Committee in the rooms of the Society.

Wednesday Evening

Reception and subscription dinner tendered to Prof. John E. Sweet, Honorary Member and Past-President, in celebration of his eightieth birthday and in recognition of his services to the engineering profession.

Thursday Morning, December 5

JOINT SESSION IN CHARGE OF SUB-COMMITTEES ON MACHINE SHOP PRACTICE AND IRON AND STEEL

(Papers contributed by Sub-Committee on Machine Shop Practice)

Report of Sub-Committee: THE DEVELOPMENT OF MACHINE SHOP PRACTICE DURING THE LAST DECADE.

No discussion.

THE VAUCLAIN DRILL, A. C. Vauclain and Henry V. Wille.

Discussed by J. S. Bancroft, H. P. Fairfield.

EFFICIENT PRODUCTION OF CYLINDRICAL WORK, C. H. Norton.

Discussed by R. H. Rice, H. P. Fairfield, A. A. Alden, Wm. Kent.

INCREASE OF BORE OF HIGH-SPEED WHEELS BY CENTRIFUGAL STRESS, Sanford A. Moss. (Contributed through the courtesy of the Boston Local Committee.)

Discussed by R. H. Rice, Wm. Kent, W. H. Kenerson, E. A. Sperry.

INVESTIGATION OF EFFICIENCY OF WORM GEARING FOR AUTOMOBILE TRANSMISSION, Wm. H. Kenerson.

Discussed by Elmer A. Sperry, R. H. Rice, Wm. Kent, S. A. Moss, W. C. Marshall.

THE STRENGTH OF GEAR TEETH, Guido H. Marx.

Discussed by L. D. Burlingame, R. E. Flanders, W. S. Huson, W. H. Diefendorf, J. S. Bancroft, Wm. Kent, W. H. Kenerson, C. H. Norton, W. C. Marshall, T. M. Phetteplace.

(Paper contributed by Sub-Committee on Iron and Steel)

CASE CARBONIZING, Marcus T. Lothrop.

Discussed by B. E. Bosler, R. R. Abbott, Albert Sauveur, H. D. Hibbard, A. H. Annin, J. A. Matthews.

RAILROAD SESSION

(Papers contributed by Sub-Committee on Railroads)

TRAIN LIGHTING, H. A. Currie and Benjamin F. Wood.

Discussed by R. M. Dixon, W. L. Bliss, Mr. Rockleton, C. D. Young, Mr. Sloan.

FACTORS IN THE SELECTION OF LOCOMOTIVES IN RELATION TO THE ECONOMICS OF RAILWAY OPERATIONS, O. S. Beyer, Jr.

Discussed by H. H. Vaughan, Simon Hoffman, C. C. Trump, Mr. Gibbs, C. D. Young, G. R. Henderson, F. F. Gaines, W. R. Keisel, Jr.

CEMENT SESSION

(Papers contributed by Sub-Committee on Cement Manufacture)

SOME REMARKS ON THE DEPRECIATION FACTOR IN THE COST OF PRODUCING PORTLAND CEMENT, Frederick H. Lewis.

Discussed by G. S. Brown.

THE PREVENTION OF MISSED FIRES IN BLASTING, W. H. Mason.

THE DETERIORATION AND SPONTANEOUS COMBUSTION OF GAS COAL, Perry Barker.

Papers discussed as a whole by R. K. Meade, R. C. Carpenter, Mr. Sayer, Mr. Brobston, P. H. Wilson.

Thursday Afternoon

SESSION ON FLUID FLOW

MEASUREMENT OF AIR IN FAN WORK, Chas. H. Treat.

No discussion.

THE V-NOTCH WEIR METHOD OF MEASUREMENT, D. Robert Yarnall. (Contributed through the courtesy of the Philadelphia Local Committee.)

Discussed by W. S. Giele, J. H. Brown, F. N. Connet.

THE CENTRIFUGAL BLOWER FOR HIGH PRESSURES, Henry F. Schmidt.

Discussed by R. H. Rice, C. G. deLaval, C. P. Crissey, S. A. Moss, A. E. Guy, W. H. Carrier, C. J. H. Woodbury.

MEASUREMENT OF NATURAL GAS, Thos. R. Weymouth.

Discussed by C. G. deLaval, E. A. Hitchcock, C. J. Bacon, C. C. Thomas.

RECEPTION

Reception to members and guests of the Society, given by the Ladies' Committee in the rooms of the Society.

Thursday Evening

The John Fritz Medal for 1912 was conferred upon Robert Woolston Hunt, Past-President of the Society, "for his contributions to the early development of the Bessemer process." Following the ceremonial there was a joint reception to Mr. Hunt and to the members and ladies of the four American engineering societies.

Friday Morning, December 6

ADMINISTRATION SESSION

Report of Sub-Committee on Administration: THE PRESENT STATE OF THE ART OF INDUSTRIAL MANAGEMENT.

Discussed by C. B. Going, H. P. Gillette, A. H. Church, C. B. Thompson, H. L. Gantt, J. G. Aldrich, R. T. Kent, H. M. Wilcox, F. A. Waldron, F. W. Taylor, F. G. Coburn, David Van Alstyne, Hugo Diemer, C. G. Barth, A. C. Humphreys, H. P. Kendall, Tracy Lyon, D. S. Kimball, H. H. Vaughan, Wm. Kent, R. R. Keely, J. A. Bursley, T. R. Wooley, E. C. Church.

AXIOMS CONCERNING MANUFACTURING COSTS, Henry R. Towne.

Discussed by A. C. Jackson, Augustus Smith, Wm. Kent.

MEASURING EFFICIENCY IN MANUFACTURING, Edward B. Passano.

No discussion.

NEWLY-ELECTED OFFICERS

An account of the career of Dr. W. F. M. Goss, elected president of the Society for 1912-1913, is herewith given; and also biographies of the three newly-elected officers who have not previously served on the Council: W. B. Jackson, H. M. Leland and Alfred Noble, Managers.

WILLIAM FREEMAN MYRICK GOSS

President Am.Soc.M.E.

William Freeman Myrick Goss was born in Barnstable, Mass., October 7, 1859. In the fall of 1877 he entered the then recently established mechanics arts course at the Massachusetts Institute of Technology. Upon completion of the two-year course he was appointed instructor in practical mechanics at Purdue University and at once began there the work of establishing shop laboratories. His first class of five students was given instruction in those lines of work in which he himself had just been trained. From a meager beginning, the outlook broadened rapidly. The equipment was extended, the number of students increased, and new shop laboratories were built. In 1883 he became professor of practical mechanics, a title which he held for seven years. When he began, there was no college west of the Allegheny Mountains giving systematic courses in shop practice, and there was no manual training work in any American high school. He devised courses of practice and developed series of lectures by means of which principles established in the shops could be given wider application. It was a day when school officials were becoming interested in training students in the manual arts, and many distinguished visitors came to see the work of the Purdue laboratories. The great cities of Chicago, Toledo, Louisville and Indianapolis each in turn sought its aid in the establishment of their manual training schools. Certain forms of equipment, especially forges and lathes, originally designed and constructed at Purdue, were made and supplied as complete equipment to school boards in distant localities where new courses of shop practice were being organized. In many such ways the work at Purdue had an important part in ushering in an educational movement of unusual significance.

In 1889, after ten years of this work, Professor Goss was given a leave of absence, and took up his residence in Boston, where he continued from April of that year to a year from the following September. Some work was done at the Massachusetts Institute of Technology, but the greater part of the time was given to self-directed reading and study. In the spring of 1890 he was appointed professor of experimental enginering, and he undertook the active duties of his new office in the fall of that year. Having developed laboratories for elementary training, it was now his task to build laboratories for advanced engineering work. A modest steam engineering laboratory equipped with a compound Corliss engine and a few testing machines was soon in operation. Plans for an extensive engineering building (Purdue's present engineering laboratory) were developed and by the fall of 1891 a portion of the building was constructed. A significant part of the equipment of the new laboratory was a locomotive testing plant designed to serve in an experimental study of locomotive problems in much the same way that an experimental stationary plant could be used in studying the problems of design affecting the performance of stationary engines. This locomotive testing plant was the first of its kind. It was designed in the summer of 1891 while the building which was to contain it was in the process of erection, and was in successful operation in the late fall of the same year. An incident in the process of installing this plant was that of transporting a 100,000-lb. locomotive over the corn-fields and highways which intervened between the nearest track and the laboratory, a distance by the course taken of about a mile and a half. The opportunities which were presented to its possessors at once attracted the attention of motive power men and of steam engineers. So meager was the information concerning the performance of locomotives that every fragment of truth, however simple or easily obtained, at once became a matter of public interest. The evaporative capacity of the locomotive boiler, its efficiency at difficult rates of power, the power and efficiency of the cylinders, and the effect upon power and efficiency of changes in speed or cut-off were all matters which previous to the introduction of this plant had been but little understood even by those best informed. The behavior of the various parts of the machine as a mechanism and especially the effects produced by the action of the counterbalance in the locomotive drive wheels were all matters concerning which people had theories, but which were first actually developed by the accurate processes of the laboratory at the Purdue plant. Associations of railroad men gave their encouragement and sometimes financial assistance in increasing the output of the plant. The Master Car Builders' Association made the Purdue laboratories its official testing station and was instrumental in installing there a considerable amount of useful and expensive apparatus. The laboratory became an active center for testing not only locomotives, locomotive fuels and locomotive lubricants, but also details of car construction such as wheels, axles, draft-gears, couplers and brake-shoes. The problems awaiting solution were always numerous, and the professor in charge was kept busy outlining the means to be employed in solving them. He was in the beginning responsible not only for the effective use of the railroad equipment to which reference has already been made, but also for the development of laboratories and courses in materials testing, in hydraulics and in the general field of theoretical and applied thermodynamics. He built buildings, purchased and installed equipment, and in many cases the equipment installed was of his design, and he was required to meet the reasonable expectations of an ever increasing body of students. Hundreds of men who were students at Purdue in the early nineties can testify to the variety of the activities which in their day were in progress in the engineering laboratories.

In 1899 Professor Goss was again granted a year's leave of absence which he spent in travel and study abroad, chiefly in Germany. Upon his return he was appointed Dean of the Schools of Engineering, an office which he continued to hold throughout the remaining eight years of his residence at Purdue. In 1907 he resigned his position at Purdue, after twenty-eight years of service, to take up what seemed to him the larger and more responsible duties of his present office, namely, that of Dean of the College of Engineering of the University of Illinois.

Professor Goss was given the honorary degree of Master of Arts by Wabash College in 1888 and the honorary degree of

Doctor of Engineering by the University of Illinois in 1904. He has been a member of the Society since 1885, and a member of the American Society for Testing Materials and of the Society for the Promotion of Engineering Education from their organization. He was a member of the Executive Committee of the National Advisory Board on Fuels and Structural Materials, and a member of the Jury of Awards in the Transportation Department of the World's Fair of Chicago in 1893. He is a member of the Master Car Builders' Association, of the Master Mechanics' Association, of the Illinois Academy of Science and of the Western Society of Engineers. He is a fellow of the American Society for the Advancement of Science, a member and past-president of the Western Railway Club and was the Chairman of the Advisory Committee organized by the Pennsylvania Railway Company to direct its work in locomotive testing at the Louisiana Purchase Exposition. For many years he was a contributing editor to the Railroad Gazette. His contributions to technical literature have been numerous. Probably his best known work is that which deals with the locomotive. His books on Locomotive Performance and Locomotive Sparks are records of personal researches which are known to most railroad men and to most students of locomotive design. Numerous researches conducted under the patronage of various associations are available only in the proceedings of these associations. Besides these, two noteworthy pieces of work were done under the patronage of the Carnegie Institution of Washington, the results of which are presented in two volumes, one entitled High Steam Pressures in Locomotive Service and the other Superheated Steam in Locomotive Service.

MANAGERS

WILLIAM BENJAMIN JACKSON

William B. Jackson was born June 22, 1870 at Kennett Square, Pa. He received his education at the Pennsylvania State College from which he was graduated in 1890 with the degree of B.S., and in 1895 he received the advance degree of M. E. From 1890 to 1893 he was in the El Paso County Bank at Colorado Springs. Colo. and the following year had charge of the Pennsylvania Mining Exhibit at the Chicago World's Fair, following which he joined the United Electric Light and Power Company of New

York. Later he accepted a position with the Stanley Electric Manufacturing Company in their shops and testing department and subsequently was made engineer in charge of the specification department. In 1895 he was transferred to Chicago as engineer for the northwest, in charge of all installation and engineering work in that district. Later he became manager of the Lowell Water and Light Company and Peninsular Light, Power and Heat Company, which transmitted electric power from Lowell, Mich., to Grand Rapids and there distributed it. This was the first high tension electric transmission system to be started east of the Rocky Mountains. There he devised a system of charges for electric light and power based upon a readiness to serve to which was added an equitable charge for each unit of power actually used, a system which has become widely recognized as an equitable one for both customer and supply company. In 1897 he was stationed at the West New Brighton plant of the New York and Staten Island Electric Company, and later assumed the duties of superintendent and chief engineer of that system. In 1899 Mr. Jackson entered the employ of the Colorado Electric Power Company with the duties of general superintendent and chief engineer. In 1901 he reentered the employ of the Stanley Electric Manufacturing Company as traveling engineer, having charge of the examinations of and reports upon all lighting and power projects brought to the attention of his company. While in this position he laid out in detail the complete electrical equipment, including the making of the estimates and specification for the 20,000-h.p. hydroelectric generating station of the Yorkhaven Water and Power Company upon the Susquehanna River, and carried out work for this company in Austria and Hungary. Up to this time his experience included pioneer work in the manufacture of polyphase electrical apparatus and the installation and operation of central stations and electrical transmissions, including the early paralleling of engine driven and water driven alternators, and the handling and repair of high voltage transmission circuits while alive. In 1902 he left the Stanley Manufacturing Company and became associated with Dugald C. Jackson of Madison, Wis., in the consulting engineering business under the firm name of D. C. and Wm. B. Jackson. In 1907 his firm moved from Madison and established its main office in Chicago, and shortly after a second office in Boston, Mass. It has been occupied in the design and supervision of the construction of important electrical projects; upon examinations and reports upon engineering projects and in the laying out and carrying out of improvements of the physical and operating features of electrical properties; the detailed valuations of electrical properties; the determination of just rates for charges of service of electric light, electric railway and telephone properties; and other matters of like character.

Mr. Jackson is a member of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Gas Institute, the Western Society of Engineers, the National Electric Light Association, and the American Street and Interurban Railway Association.

HENRY MARTYN LELAND

Henry Martyn Leland was born at Danville, Vt., February 16, 1843. His early life was spent upon a farm and his education was such as was afforded in the country schoolhouse. After leaving school he worked for one year at making carriage wheels at Worcester, Mass., and in 1859 was apprenticed to learn the machinists' trade with the Geo. Crompton Loom Works at Worcester, now the Knowles-Crompton Loom Works. Completing this apprenticeship in 1862, he worked during the balance of the Civil War in the U. S. Armory, Springfield, Mass., making the tools that were used in the manufacture of rifles for the war. After the war he began a service of one year in the Colts Armory at Hartford, Conn., and then returned to Worcester where he worked as machinist and tool maker. Believing the Brown & Sharpe Manufacturing Company of Providence to represent the highest type of manufacturing concern he moved to Providence in 1872 and entered their employ as tool maker, becoming foreman of the sewing machine department in a few years. Mr. Leland remained with this company about twenty years, when he yielded to the appeals of the growing west.

In 1890 he established the Leland & Faulconer Manufacturing Company in Detroit, Mich., devoting his energies to the manufacture of special machinery, particularly the internal-combustion engine for naphtha launches. This naturally led to an early identification with the automobile industry, and the Cadillac Automobile Company was organized that he might have a market for his engines. In 1905 the Leland & Faulconer Manufacturing Company and the Cadillac Automobile Company were consolidated to form the Cadillac Motor Car Company, with Mr. Leland as its manager, a position which he still holds.

ALFRED NOBLE

Alfred Noble was born August 7, 1844 at Livonia, Mich. At the age of eighteen he enlisted as a private in the 24th Michigan Infantry, and served continuously in the army of the Potomac until February 1865; he was on post duty until June 1865, and was finally discharged with the rank of sergeant at the close of the war. Mr. Noble then obtained a position as clerk in the War Department at Washington, and while there prepared himself to enter the University of Michigan. He was graduated in 1870 although he was absent much of the time during his course, being employed as clerk and then as assistant engineer on river and harbor work. After graduation he was placed in local charge of the improvement of St. Mary's Falls Canal and St. Mary's River where he continued for twelve years. During this period the first great masonry lock was built at the Sault, which was at the time of its construction the largest canal lock in the world. In 1882 Mr. Noble resigned from the government service and went to Louisiana where he was resident engineer on the construction of the Red River Bridge at Shreveport. In the spring of 1883 he was appointed general assistant engineer of the Northern Pacific Railroad. He continued in the position for three years, and had charge of the building of bridges across Snake River, Clark's Fork of the Columbia River and St. Louis Bay, and the foundations and erection of the Marent Gulch viaduct. In August 1886 Mr. Noble came to New York to supervise the construction of the Washington steel arch bridge over the Harlem River. In 1887 he took charge of the erection of the Cairo bridge over the Ohio River, and was also connected with the construction of the great cantilever bridge over the Mississippi River at Memphis. From 1892 to 1894 as assistant chief engineer he had charge of the Bellefontaine and Leavenworth bridges over the Mississippi, as well as the bridge at Alton.

Mr. Noble came into national prominence through his appointment in 1895 as a member of the first Nicaragua Canal Commission. The report of this commision, that while the high level route proposed by the Maritime Canal Company was feasible, its adoption was inadvisable until alternative routes had been explored, lead to the appointment of the second Nicaragua Canal Commission of 1897, and later of the Isthmian Canal Commission of 1899, of which Mr. Noble was also a member. This is the body which determined on the Panama route as the most practicable.

Mr. Noble's work on the United States Deep Waterway Commission from 1897 to 1900 is hardly less important in public service than his work on the Isthmian Canal Commission. In 1902 he was appointed chief engineer of the East River Division of the New York extension of the Pennsylvania Railroad, in which capacity he served until 1909.

He is a past-president of the American Society of Civil Engineers, the Western Society of Engineers, and a member of the Institution of Civil Engineers of Great Britain.

REPORT OF FIFTEENTH INTERNATIONAL CONGRESS ON HYGIENE AND DEMOGRAPHY

To the Council:

The Fifteenth International Congress on Hygiene and Demography was held in Washington, D. C., from September 23 to 28, inclusive, in response to an invitation extended by the President of the United States. These congresses are held at irregular intervals of a few years apart and are one of the many world-wide movements to disseminate knowledge. Their specific object is to increase the world's knowledge of and to encourage the study of matters relating to public health and welfare and to vital and social statistics and their application to the comparative study of races.

The congress was divided into nine sections, as follows: (1) Hygienic Microbiology and Parasitology; (2) Dietetic Hygiene; Hygienic Physiology; (3) Hygiene of Infancy and Childhood: School of Hygiene; (4) Industrial and Occupational Hygiene; (5) Control of Infectious Diseases; (6) State and Municipal Diseases; (7) Hygiene of Traffic and Transportation; (8) Military, Naval and Tropical Hygiene; (9) Demography. In addition to these sections, there was organized an exhibition, illustrating human welfare and demography, which was open from September 16 to October 4.

Some 27 foreign governments and 48 states of the Union accepted the invitation to attend this congress, which was the first of the series to be held on the continent of America. The exhibition was participated in by many federal bureaus, states, cities, scientific organizations, and institutions of learning and research. This was the first exhibition in the United States which covered all phases of hygiene, although there have been many exhibitions of similar character confined to single problems.

Among the exhibits, there were many which showed careful preparation and were worthy of their contributors. Especially noted were the exhibits made by U. S. Public Health Service, the

U. S. Army, the U. S. Navy, the American Museum of Natural History of New York, New York State, the Metropolitan Sewerage Commission of New York, the New York City Department of Health, various State Boards of Health, the exhibitions on Sex Hygiene, on Mental Hygiene, on Prevention of Industrial Accidents, and on Welfare of Employees in Manufacturing Establishments.

Many delegates from all parts of the world attended the congress and exhibition, and the scientific delegates representing foreign countries were of a high order.

The congress was most successful. The papers presented in all the sections were of a distinctly high character, well worthy of the efforts which were made to make this congress notable in the series.

As sanitary science has passed the stage of infancy and has become widely recognized, the purpose of the congress and exhibition was to bring before the public, practical methods for the prevention of diseases and the improvement of living conditions.

The object of these congresses is to effect this result

a By a conference of the foremost sanitary authorities from all parts of the world, whereby the latest data on sanitation and the prevention of diseases would be presented for discussion.

b By educating the general public to the necessity of concerted effort by extending and coördinating the work of federal, state, municipal and private health agencies.

c By demonstrating the best work done in public health, civic welfare and the prevention of disease through an exhibition.

As former congresses have been held in the capitals of Europe, it has not been possible for many American delegates to attend. At this congress there were many American scientists and others interested in hygiene, who had an opportunity of meeting many of the best foreign sanitary specialists. This opportunity will, undoubtedly, tend to improve the conditions existing in the United States, such as the extension of our system of vital statistics, the prevention of infant mortality, the sanitary control of food supplies, school and industrial hygiene, typhoid fever and hookworm, the cure and prevention of tropical diseases, and federal, state and municipal organization for the preservation of public health.

The transactions of the congress will be published so that the knowledge may become available to all interested in the matters presented.

As the engineer is becoming more and more an important factor in improving hygienic conditions in our modern civilization, it is a source of great satisfaction to know that the engineers of this country took a deep and active interest in this congress.

Respectfully submitted,
H. de B. Parsons, *Honorary Vice-President*

A PROPOSED CODE OF ETHICS FOR ENGINEERS

A committee was appointed by the Council on April 9, 1912 to draft a code of ethics for adoption by the Society. At the Council Meeting of December 6, this Committee submitted a proposed code which it recommended should be presented to the Society's members for comment and criticism before any action was taken upon it. The proposed code is printed herewith. Members are urged to give it careful study and to forward to the Secretary any criticisms or suggestions for its improvement.

The basis of the present code is that adopted by the American Institute of Electrical Engineers and that now before the Boston Society of Civil Engineers for adoption, with additional sections, one in particular providing for a new standing committee of the Society. It has seemed to the Committee that any code which could be drafted would need to be improved, modified and added to by the results of experience, and that this work is important enough to the profession's welfare so that a special committee might well devote time to it. Such a committee would be in effect an arbitration committee, and its decisions would serve to put on record the consensus of the profession as to what constitutes honorable professional conduct.

In presenting the proposed code to the Council, the Committee emphasizes the fact that no code can define the duties and obligations of engineers under all possible circumstances and the proposed code merely attempts to cover those relations concerning which questions most frequently arise in engineering practice.

The Committee also urges that since the maintenance of honorable professional conduct by its members is as important to the welfare of the profession as wide knowledge and sound judgment on technical matters, it is as properly a function of the Society to furnish its members with some guide as to proper standards of professional conduct as it is to aid them by the formulation of standards relating to technical matters.

The code follows:

PRELIMINARY DRAFT OF CODE OF ETHICS

A GENERAL PRINCIPLES

1 It is not assumed that this code shall define in detail the duties and obligations of engineers under all possible circumstances. It is an axiom that engineers in all their professional relations should be governed by principles of honor, honesty, strict fidelity to trusts imposed upon them and courteous behavior toward all. The following sections are framed to cover situations arising most frequently in engineers' work.

2 It is the duty of engineers to satisfy themselves to the best of their ability that the enterprises with which they become identified are of legitimate character. If an engineer after becoming associated with an enterprise finds it to be of questionable character, he should sever his connection with it as soon as practicable, avoiding in so doing reflections on his previous associates.

B THE ENGINEER'S RELATIONS TO CLIENT OR EMPLOYER

3 The engineer should consider the protection of a client's or employer's interests his first obligation, and therefore should avoid every act contrary to this duty. If any other consideration, such as professional obligations or restrictions, interfere with his meeting the legitimate expectation of a client or employer, the engineer should so inform him.

4 An engineer cannot honorably accept compensation, financial or otherwise, from two or more parties having conflicting interests without the consent of all parties. The engineer, in whatever capacity, whether consulting, designing, installing, or operating, must not accept commissions, directly or indirectly, from parties dealing with his client or employer.

5 An engineer called upon to decide on the use of inventions, apparatus, or anything in which he has a financial interest, should make his status clearly understood by those employing him,

6 An engineer in independent practice may be employed by more than one party, when the interests of the several parties do not conflict; and it should be understood that he is not expected to devote his entire time to the work of one, but is free to carry out other engagements. A consulting engineer permanently retained by a party, should notify other prospective clients of this affiliation before entering into relations with them, if, in his opinion, the interests might conflict.

7 Before any consulting engineer takes over the work of another consulting engineer he should ask the client his reasons for desiring to change engineers and unless the consulting engineer is entirely satisfied that the client has good and sufficient reasons for making the change he should confer with the present incumbent before accepting the work.

8 Consultations should be encouraged in cases of doubt or unusual responsibility. The aim should be to give the client the advantage of collective skill. Discussions should be confidential. Consulting engineers should not say or do anything to impair confidence in the engineer in charge unless it is apparent that he is wholly incompetent or the interests of the profession so require.

9 Engineers acting as experts in legal and other cases, in making reports and testifying, should not depart from the true statement of results based on sound engineering principles. To base reports or testimony upon theories not so founded is unprofessional.

10 An engineer should make every effort to remedy dangerous defects in apparatus or structures or dangerous conditions of operation, and should immediately bring these to the attention of his client or employer. As failure of any engineering work reflects upon the whole profession, every engineer owes it to his professional associates as well as to himself that a reasonable degree of safety be provided in all work undertaken.

C OWNERSHIP OF ENGINEERING RECORDS AND DATA

11 It is desirable that an engineer undertaking for others work in connection with which he may make improvements, inventions, plans, designs or other records, should first enter into an agreement regarding their ownership.

12 If an engineer uses information which is not common knowledge or public property, but which he obtains from a client or employer, resulting in plans, designs, or other records, these should be regarded as the property of his client or employer.

13 If a consulting engineer uses only his own knowledge, or information which by prior publication, or otherwise, is public property and obtains no engineering data from a client or employer, except performance specifications or routine information; then in the absence of an agreement to the contrary, the results

in the form of inventions, plans, designs, or other records should be regarded as the property of the engineer, and the client or employer should be entitled to their use only in the case for which the engineer was employed.

14 All work and results accomplished by an engineer in independent practice in the form of inventions, plans, designs, or other records, which are outside of the field of engineering for which a client or employer has retained him, should be regarded as the engineer's property unless there is an agreement to the contrary.

15 When an engineer or manufacturer builds apparatus from designs supplied to him by a customer, the designs remain the property of the customer and should not be duplicated by the engineer or manufacturer for others without express permission. When the engineer or manufacturer and a customer jointly work out designs and plans or develop inventions, a clear understanding should be reached before the beginning of the work regarding the respective rights or ownership in any inventions, designs, or matters of similar character, that may result.

16 Any engineering data or information which an engineer obtains from his client or employer, or which he creates as a result of such information, must be considered confidential by the engineer; and while he is justified in using such data or information in his own practice as forming part of his professional experience, its publication without express permission is improper.

17 Designs, data, records and notes made by an employe and referring exclusively to his employer's work, should be regarded as his employer's property.

18 A customer, in buying apparatus, does not acquire any right in its design, but only the use of the apparatus purchased. A client does not acquire any right to the plans made by a consulting engineer except for the specific case for which they were made, unless there is an agreement to the contrary.

D THE ENGINEER'S RELATIONS TO THE PUBLIC

19 The engineer should endeavor to assist the public to a fair and correct general understanding of engineering matters, to extend the general knowledge of engineering, and to discourage the appearance of untrue, unfair or exaggerated statements on engineering subjects in the press or elsewhere, especially if these

statements may lead to, or are made for the purpose of, inducing the public to participate in unworthy enterprises.

20 Technical discussions and criticisms of engineering subjects should not be conducted in the public press, but before engineering societies or in technical publications.

21 It is desirable that the first technical descriptions of inventions, or other engineering advances should not be made through the public press, but before engineering societies or through technical publications.

22 It is unprofessional to give an opinion on a subject without being fully informed as to all the facts relating thereto and as to the purposes for which the information is asked. The opinion should contain a full statement of the conditions under which it applies.

23 Engineers engaged in private practice should limit their advertising to professional cards and modest signs in conformity with the practice of other professions.

E THE ENGINEER'S RELATIONS TO THE ENGINEERING FRATERNITY

24 The engineer should take an interest in and assist his fellow engineers by exchange of general information and experience, by instruction and similar aid, through the engineering societies, the engineering schools, or other means. He should endeavor to protect all reputable engineers from misrepresentation.

25 The engineer should take care that credit for engineering work is attributed to those who, so far as his knowledge of the matter goes, are the real authors of such work.

26 Criticism of the work of one engineer by another should be broad and generous with the facts plainly stated. The success or failure of one member reflects credit or discredit on the whole profession.

27 The attitude of superiors toward subordinates should be that of helpfulness and encouragement. The attitude of subordinates to superiors should be one of loyalty and diligent support. The treatment of each by the other should be open and frank.

28 The attitude of an engineer toward contractors should be one of helpful coöperation. Tact and courtesy should be combined with firmness. An engineer should hold a judicial attitude toward both parties to a contract for whose execution he is responsible.

29 An engineer in responsible charge of work should not permit non-technical persons to over-rule his engineering judgment on purely engineering grounds.

F INTERPRETATION

30 If two or more engineers, members of this Society, disagree as to the interpretation of this code, or as to the proper rules of conduct which should govern them in professional relations to each other, they may agree to refer the matter to a standing committee of the Society on the interpretation of the code. Each party shall submit a statement of his position in writing, and the committee shall render a decision. A permanent record shall be made of the cases so submitted and decided.

31 Amendments or addtions to this code may be made by the standing committee on interpretation of the code, subject to the approval of the Council.

CHAS. WHITING BAKER, *Chairman*
CHAS. T. MAIN,
E. D. MEIER
SPENCER MILLER
C. R. RICHARDS

Committee on Code of Ethics

REPORT OF COMMITTEE ON NATIONAL MUSEUM

The value of museums as educational factors has been recognized by the foremost nations of all periods of civilization. There are historical museums of arms and instruments of destruction, museums of costumes, of natural history, of paintings and sculpture, and of fabrics of various kinds. Liberal sums are spent annually by archeological societies for excavations in foreign lands tending to resurrect the scanty relics of vanished empires, great in the dawn of civilization.

The great works of the engineer and mechanic built upon scientific research, which have given man the command and the use of the forces of nature, to an extent no Pharaoh nor Caesar could have imagined in his wildest dreams, have had but scant recognition in literature, in art and in collections.

That national museums illustrative of this greatest uplift of humanity should be created, is recognized by all who are able to understand and estimate their paramount importance. Germany has erected the first comprehensive museum of the masterpieces of science and the technical arts at Munich.

In less than five years their marvellous success in covering with important exhibits many acres of floor space in a former art gallery and a spacious cavalry barracks loaned by the Bavarian Government, encouraged the managers to invest the millions cheerfully supplied by German industrials in a permanent building on an island in the Isar, now nearing completion.

Last April a commission of five, with as many engineer assistants, was sent to this country to look for more contributions of machines, models, drawings, etc., to enable them to add an American section to each of their main divisions and to encourage American engineers to begin a similar movement.

America owes its greatness to the buoyant courage and skill with which its artisans and engineers accepted and solved the new and gigantic problems which the conquest of a new continent imposed. Their clear conception, untrammeled by traditions and their cheerful, unremitting labor have built up, from a mere fringe of agricultural colonies on the seaboard, the greatest industrial community the world has yet seen, and that in the short space of but little more than a single century.

The doing has so absorbed our energies that no one has found time for the recording. We who profit by the labors of these pioneers owe them the searching out and preserving of the records of their work.

Nearly thirty years ago, our venerable Past President John E. Sweet wrote:

> Let us hope that if the high tide of human progress is sweeping on toward a more useful education, that the day may not be far away when *he who knows what to do and how to do it* will be regarded as the equal of *him who only knows what has been done* and who did it.

and

> May the time come when we shall have a museum in which there shall be gathered the finest specimens of workmanship with the masterpieces of our great engineers.

Let us begin now. Let every man familiar with any one of our many industries search out such relics as still exist in drawings, in models, in descriptions or specifications and above all, in once used but now outclassed or outworn tools, machines and structures which represent steps in industrial progress. Let him rescue them from the oblivion of the scrapheap and notify this committee of their existence, condition and location, and explain to the present owners their educational and sentimental value. This knowledge of what is available for preservation must precede the planning of any building to house them and will largely aid in inducing cities, corporations, and individuals to proffer the financial aid necessary to build up some great National Museum of the Industrial Arts.

The movement once begun, its educational value made manifest, we shall find other museums growing up in various communities illustrating special industries like the beautiful collection of textile fabrics in Lyons, or that of the exquisite hand forged armor in the Bargello in Florence.

" Peace has its victories not less renowned than War." One of the members of our committee, Dr. Kunz, who is also chairman of the plan and scope committee for the celebration of the century of peace between England and America, has proposed such an industrial museum as the fittest expression of our pride and joy in this achievement. The long peace and the great industrial development are coincident in time. Are they not also the effects of the same causes?

Not where and how we commence, but that we commence, is of paramount importance. Our main effort should be to preserve the landmarks of our journey to a higher civilzation and thus write in enduring materials of our own fashioning, the true history of the American people. The details of how best to do it we can confidently entrust to a generation at present completing the greatest task of engineering ever undertaken.

E. D. Meier, *Chairman*
George F. Kunz
Ambrose Swasey
George Mesta
H. G. Reist
Committee on National Museum

THE PRESENT OPPORTUNITIES AND CONSEQUENT RESPONSIBILITIES OF THE ENGINEER

By Alexander C. Humphreys, New York

President of the Society

In compliance with a custom now time-honored in The American Society of Mechanical Engineers, it falls to my lot, by reason of the honor you conferred upon me a year ago, to open this 33d Annual Meeting with the President's address.

I have selected as my text: "The Present Opportunities and Consequent Responsibilities of the Engineer."

While speaking from my own experience as an engineer, industrial manager, and president of a college of engineering, supplemented by my experiences for some years past as an officer of this Society, I shall call to my aid the past-presidents of the Society. I shall touch on a number of important moot questions, necessarily briefly, and, although I shall do my utmost to avoid misunderstanding and misinterpretation, I know in advance that in this I cannot be entirely successful. We all have had opportunities to observe the generally inconclusive results from the discussions of papers read before our engineering and other societies due to this failure to secure an agreement of minds. The chances for misunderstanding will be increased because I shall not attempt to impose upon your good nature by reading my paper at length.

Doubtless we are all prepared to agree that special qualifications, natural and acquired, must necessarily involve a commensurate responsibility to employ those qualifications in effective service. For many years past I have been deeply impressed with the particular responsibility of the engineer to the community,

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Presented at the Annual Meeting 1912, of The American Society of Mechanical Engineers.

by reason of his special qualifications. If, through his special qualifications, he is competent to render service to the community at large, that service should not be limited to his particular field of work.

My proposition then is that to-day, by reason of the present complex conditions surrounding the industries, there are offered to us as engineers opportunities for public service which are exceptional; and our responsibilities are the greater because these conditions were in part created by members of our profession. These opportunities are offered to us; if we refuse to accept them, we assume a grave responsibility. The fact that others are more than willing to take the lead in the effort to solve the problems which are threatening our well-being as a nation does not relieve us of responsibility, but rather to the contrary. If we leave it to the lawyers, theoretical economists, and others, to shape the measures of reform, then, just so far as we could have bettered the result, the reproach must rest upon us. As far as possible, the work of reform should be the result of sincere coöperation on the part of all conscientious and competent members of the body politic.

If we consider their addresses collectively, I find that there is little or nothing to be said as to the opportunities and responsibilities of the engineer which has not already been said by our past-presidents.

The education of the engineer is necessarily involved in the question of his responsibility. Some of the authors of these addresses have given expression to decided opinions on this subject of engineering education, and I have no doubt that the authors were not all in entire agreement; and yet, as I read their papers, I find that it is not difficult to harmonize the seeming differences.

Let me recall to your minds these addresses and let me quote briefly from them such parts as are more particularly applicable to my present purpose:

February 16, 1880. "The Field of Mechanical Engineering" by Alexander L. Holley, Chairman of Preliminary Meeting. Five pages only of print, but prophetic as to the future of our Society. He anticipates the late movement to broaden our field of usefulness by the appointment of sub-committees of the Committee on Meetings in the interest of certain "departments of industry." Holley says:

> Mechanical Engineering underlies all Engineering. . . . In these leading departments of industry which, at first thought, the public would deem quite outside of mechanical engineering, how completely is this art incorporated with their every detail. . . . The genius that reaches the harmony of perfect construction and perfect beauty (which are interchangeable terms) in Nature's inert materials may not be loftier than that which as perfectly utilizes and governs her wild and capricious forces.

Holley advises the inclusion of several classes of membership and speaks of "the advantages of the association of business men with engineers in these societies." He also recommends the holding of meetings in different parts of the country.

Organization meeting, April 7, 1880, "On the Character of the Association, the Nature of its Work and the Methods by which that Work is to be done." Inaugural Address by Robert H. Thurston, first President.

> We have often, and sometimes long, suffered from the effects of legal enactments made by ignorant legislators, influenced by personal motives and the selfish advice of scheming lobbyists. This will be corrected when business men have learned to organize and to act concertedly whenever the business of the country is liable to be affected by legislation. It is their right to be heard fully and patiently, and it is their duty to take such action as will secure for them full consideration. . . .
>
> Ours is the duty to discover facts and to deduce laws bearing upon every application of mechanical science and art in field, workshop, school or household.

Annual Meeting, 1881. "Our Progress in Mechanical Engineering," by Robert H. Thurston, President.

> We are everywhere giving up the use of that expensive and perishable material wood, and the weak and brittle minerals, and are substituting for them iron and steel. . . . Machinery speeded up, product increased, labor diminished, cost lessened and machinery given greater automatism and higher efficiency both in making ordinary goods and in adaptation to finer grades. The compressed air engine, the petroleum engine and the gas engine are all just coming forward. . . . The solar motor proposed by Ericsson, the inevitably coming motor of some far-distant epoch has, as yet, made no progress beyond the plans and experiments of the inventor. . . .
>
> Double hulls and transverse bulkheads will make these great vessels safe even against the shock of collision with an iceberg. . . .
>
> The navigation of the air is very possibly on the point of real advancement. . . . Thus we are apparently approaching, though still, perhaps, far from this goal, and we may barely venture to hope that the engineer who is to combine the elements of success, all of which are becoming deter-

mined, will in our own day win the fame that awaits the first successful builder of a flying-machine.

. . . .

But the individual must be taught, not simply *permitted* to learn as best he can. Education, directed effectively with the object of giving, in least time and at least cost, a preparation for all the duties coming to the learner, whether in daily toil or social life, is called for.

Annual Meeting, 1882. "The Mechanical Engineer, His Work and His Policy," by Robert H. Thurston, President.

Nature rarely turns a sharp corner in any of her great movements. . . . It is from us, if from any body of men, that the world should expect a complete and thoroughly satisfactory practical solution of the so-called labor problem. . . . The elements of social economy are yet to become known to our people; the most obvious principles of statesmanship are yet to be learned by our legislators, and we have still to look forward to a time when our men of business and our working people shall be fairly and respectfully considered by those who direct public policy. . . .

Such bodies as this must aid our legislative assemblies in developing a *Scheme of Industrial Organization* that shall exhibit highest possible efficiency—one that will prepare the children and youth of the country to enter upon lives of maximum usefulness, and to do the work that may be given them to do with ease and comfort while, at the same time, aiding them to attain health, happiness and content, even if not independence and wealth.

The author speaks for a "common school system of general education, which shall give all young children tuition in the three studies which are the foundation of all education, and which shall be administered under compulsory law."

Annual Meeting, 1883. President E. D. Leavitt did not deliver an address.

Annual Meeting, 1884. An address without title, by John E. Sweet, President. Contrasts and compares Mechanics with Science and Literature.

The educated portion of the world look upon a book not merely as so much paper, and printing and binding, but as the thoughtful work of the author, while the same class almost universally look upon a machine as so much wood and iron, running their minds forward to what it does, and how much it will save, and what the patent it worth, rather than backward to the brain work of its author. . . .

Gauging the value of the thing on the democratic principle of the greatest good to the greatest number, the inventors of agricultural machinery will have few rivals. . . . "May the time come when we shall have a museum in which there shall be gathered the finest specimens of workmanship with the masterpieces of our great engineers. . . . Let us hope that if the high tide of human progress is sweeping on toward a more useful education, that the day may not be far away when he who knows what to do and how to do it will be regarded as the equal of him who only knows what has been done and who did it.

Annual Meeting, 1885. "The Mechanical Engineer, His Position and Mission," by J. F. Holloway, President.

While it is true that scientific and technical training is, and must ever be, of great advantage to the mechanical engineer, there is yet another source from which, after all, he will derive by far the most benefit, and that is—experience. Not necessarily his own experience, but the experience of others, and of all ages as well. And I know of no other way in which he can be so benefited and aided all through his life.

While none will question the value of the engineer in aiding the progress of the past, all will, I think, agree that at no time in the history of the world was he so important a factor as he is to-day. Need I ask whose triumph has contributed most to the welfare of all the world,—the generals who went over the Alps, or the Engineers who went through them? Mont Cenis and St. Gothard answer.

Annual Meeting, 1886. An address without title by Coleman Sellers, President.

I invite your consideration of a variety of topics which appear to me germane to our organization. . . .

The engineer who counts cost as nothing as compared to the result, who holds himself above the consideration of dollars and cents, has missed his vocation. . . . I am safe in saying that no profession requires a broader education than that of the mechanical engineer. He must be a physicist, a merchant, a lawyer, a chemist, and he should know how to express himself in his mother tongue and be master of the modern languages far enough to have access to the scientific publications of other countries. . . . The engineer must of necessity be a hard student; his school days never end. . . . What will fit him to enter the workshop in better condition than now, will fit him better also for any other walk in life. . . . Education which spoils a man for his work by placing him above manual labor through false pride will continue to do him harm.

The author expresses himself as dissatisfied with the primary schools of the country; they should better prepare for the study to follow.

In our schools we are cramming brains with what taxes the memory to the utmost, but which sends into our workshops boys who are themselves startled to find how little they know as compared to those who, almost ignorant of book-learning, are wise in the knowledge of things about them and skillful in the use of their hands.

The author approves of college sports which train eye and hand and strengthen muscles and develop manhood.

> Books, however, are not all repositories of truth. . . . We must teach the money value of knowledge and how to determine it.

He concludes:

> The American Society of Mechanical Engineers can do no better work than in devising a good system of education and compelling its introduction into our public schools. Then will those who come after us take command and lead in the industries of the world, and the products of their skill and knowledge find ready sale in all the markets of the world.

This is the man who more than any other influenced the appropriation of the E. A. Stevens endowment to establish the first college to be devoted specifically to the teaching of the science of *mechanical* engineering.

Annual Meeting, 1887. "The Engineer; His Commission and His Achievement," by George H. Babcock, President.

Quoting from Alex. L. Holley's address:

> The profession of the mechanical engineer underlies all forms of engineering as well as architecture, manufactures and commerce. . . . His commission is to "subdue the earth." . . . Discovery has followed discovery in a geometrically progressing ratio. . . . There is no good reason to doubt that he will become master of the air, as he is now master of the water, and he will fly from place to place with all the certainty and safety of a bird.

Annual Meeting, 1888. President Horace See, by reason of illness, was unable to deliver his address, but it was published in the Transactions of 1889. Opens with this verse from Cowper:

> "Knowledge and wisdom, far from being one,
> Have oft-times no connection. Knowledge dwells
> In heads replete with thoughts of other men;
> Wisdom, in minds attentive to their own.
> Knowledge is proud that he has learned so much,
> Wisdom is humble that he knows no more."

> Some contend that the American youth should occupy a higher position than that of a workman; but what is more humiliating than the spectacle of thousands of our countrymen who have no trade, who daily are compelled to beg for work as common laborers. . . . It seems to me that they (the people) would be better off in this world's goods, much better citizens, and the nation far stronger, if a greater number were reared as skilled and intelligent workmen. . . . It would be a great advantage to our youths if the common school education were modified so as to call on all of the faculties of the mind, and not rely so much on cramming the memory.

Annual Meeting, 1889. Address without title, by Henry R. Towne, President. Three topics:

a The joint excursion of American engineers to Europe the previous summer;
b The contemplated International Exhibition in 1892;
c Brief resume of affairs of Society.

> We are outgrowing our industrial childhood and are rapidly approaching a point where protection, which has done so much to foster our industries, is no longer needed to the same extent as in the past, a recognition of which fact will, in the near future, enable us to enter in competition for the markets of the world on better terms than we have ever done before.

Quotes extensively from Holley's address in 1880, and then says:

> Holley's prediction (as to the growth of the Society) has been fulfilled, but it devolves upon us to carry on the work and if we can, to do even better in the future than in the past.

He strongly recommends the holding of the Society's meetings " in all parts of the country."

Annual meeting, 1890. " The Engineer as a Scholar and Gentleman," by Oberlin Smith, President.

> As a matter of fact, the modern Engineer, if he be worthy of the name, must be a scholar as regards many important branches of knowledge. To have become this, he must possess a trained intellect and must have been through a course, whether in college or office or shop, in which he has fulfilled the most important condition of all scholarship, *by learning how to learn*. . . . True scholarship, which consists of a general knowledge of the world at large, combined with such particular knowledge of, and experience in, their chosen vocation, as to make it a success.
>
> This social aspect of professional work, and its great importance in furthering his success in life, not only in the way of pleasure but of profit and reputation, is too often ignored by big-brained young men who are full of scientific zeal, but who have not learned sufficient practical respect for the ways of the world.

Recommends strongly the study of commercial economics, paticularly accountancy. Also, *systematic* physical culture for strength and grace of body.

Annual Meeting, 1891. " The Evolution of American Rolling Mills," by Robert W. Hunt, President. An address of the highest value, historically and technically.

> But, as has so often and so fortunately happened, the difficulties and seeming hopelessness of the situation forced a solution of the particular case, and more than that, led to an invention which was destined to revolutionize the rail industry of the country.

He referred to the work of our revered past-president, John Fritz, then chief engineer of the Cambria Iron Works.

> If there were no differences of opinion and professional and commercial rivalries, we would be without progress.

Annual Meeting, 1892. "The Steam Engine in Modern Civilization," by Charles H. Loring, President. Another paper of great value, historically and technically.

> The Steam Engine may be truly called the material saviour of man. . . . The steam engine is a machine which has been the prolific parent of other machines. . . .
>
> Contemporaneous historians have but scantily drawn attention to the immense influence exerted upon modern history by the steam engine. . . . The development of the steam engine could not progress much, if any, faster than the art of boiler-making.

Annual Meeting, 1893. "The Use of Small Sizes of Anthracite Coal For Generating Steam," by Eckley B. Coxe, President. A study in considerable detail. Admirable for its practical consideration of the questions involved in the testing and valuing of coals.

> What the man who pays for the coal wants to know—and he is the one for whom the profession generally works—is how much water can be evaporated for $1, with different coals. . . . I am strongly of the opinion that the time has come when it is better for those engaged in professional investigations to give to the public the result of their investigations before they have reached a final conclusion, as it tends to bring out suggestions from others, and to gather facts which will be of great value in the work in hand.

Annual Meeting, 1894. No President's address, owing to the death of President E. F. C. Davis.

Annual Meeting, 1895. "The Modern Drop Press," by C. E. Billings, President. Briefly historical and then strictly technical. Referring to "the manufacture of the then [1854-1855] celebrated Enfield rifle for the English Government, on the interchangeable system," the author says:

> To America is thus due the credit of introducing the interchangeable system in the manufacture of firearms, sewing machines, watches, etc.

Annual Meeting, 1896. "The Progress in the Manufacture of Iron and Steel in America, and the Relation of the Engineer to it," by John Fritz, President.

> As a beginning I will make a brief allusion to the Mechanical Engineer, showing his origin and growth, and what he has accomplished in the great

field of metallurgy, and especially in the Bessemer and other important steel-making processes.

The millwright is shown as the progenitor of the mechanical and metallurgical engineer. Referring to the engineers of the iron mills at the time the Bessemer process was introduced, he says:

> This was the graduating period for them, and no set of men ever worked more faithfully or earned their diplomas more honestly than these men did. Their diplomas were not made of parchment, but of bright ideas, hard work and energy, coupled with a determination which made failure impossible.

Annual Meeting, 1897. "The Telescope Considered Historically and Practically," by Worcester R. Warner, President. (Followed by an extended discussion by John A. Brashear.) An address of great interest along the lines shown by the title. May well be recommended for reading and re-reading from time to time to those who propose that the mathematics and sciences of the past ages should be "scrapped."

Coming to comparatively modern times, the author reminds us of "that most eminent physicist, Joseph Fraunhofer of Munich. He died in 1826 but is today quoted by the physicists and astronomers of the whole world."

Annual Meeting, 1898. Address without title (but it might well be called "The Engineer"), by Charles Wallace Hunt, President.

> Each one of us . . . as it were, looks through a colored glass which gives a personal tint to the scene, colored by the effects of our environment, as well as by our personal temperament. . . .
>
> In order that we may proceed in harmony of thought, we must use words in the same sense. . . .
>
> The new discoveries of materials, of forces, and of laws which now succeed each other so rapidly, make a corresponding increase in the range of the work and the responsibility of the engineer of this present day. . . .
>
> The engineer of the user and the engineer of the maker have widely different duties. . . .
>
> These societies thus become, so to say, the saving banks of our civilization, the repositories and guardians of the results of investigations, experiments and experience that otherwise would have been lost to the world. . . .
>
> It is this great fund of information, principally accumulated during the last century, that we draw upon for material for our text books, our general treaties, and our engineering handbooks.
>
> Man builds to master, to resist or to guide the forces of Nature. If he

has rightly judged the conditions, his work stands as a permanent monument of the fact; but if otherwise, the irresistible laws of Nature will develop the defect and discover the ignorance, incompetence or error to every observer.

Annual Meeting, 1899. "Engineering in the United States Navy. Its Personnel and Matériel," by George W. Melville, President. Largely historical.

Referring to Benjamin F. Isherwood and his work on the vessels employed in our Civil War:

> He was accused of building engines which were inordinately heavy, which accusation he has never denied. To the mere office engineer this was true, but he realized what they did not, that these engines had to go into the hands of men who were largely untrained and unfamiliar with machinery. . . . To my mind this was the highest proof of his talent as a sound designer. He had the courage to invite criticism from the book-engineer in order that he might ensure success for the country.

The officers of the Navy designated as "Fighting Engineers."

Annual Meeting, 1900. "Some Landmarks in the History of the Rolling Mill," by Charles H. Morgan, President.

> I have often found it to be true that the axioms of my neighbors' trade were the problems of my own, the things by daily contact trite to him, of interest to me. . . . Watt's engine *is* the Hercules, but the rolling mill *is his club*. . . . Those were curious days in the light of to-day; when the appraised value of the West was expressed at Washington in such figurative terms as "interminable desert," "arid plain," "impassable mountains," "not worth a pinch of snuff," "region of savages and wild beasts," "deserts of shifting sands, dust, cactus, and prairie dogs." And so it was, and so it would be now, but for the products of the rolling mill.

Annual Meeting, 1901. "The Early History of Open Hearth Steel Manufacture in the United States," by Samuel T. Wellman, President.

> The starting of the works was attended with the usual mishaps which always attend the launching of a new enterprise, especially in the iron business.

This whole paper shows how success is won through costly experimenting and temporary failures. A valuable lesson for the young engineer; and particularly valuable today in connection with the appraisal of properties, which many incorrectly think should be appraised on the basis of original or reproductive cost, less depreciation as derived from some life table in connection with statement of age.

Annual Meeting, 1902. No address made by President Edwin Reynolds.

Annual Meeting, 1903. "The Money Value of Technical Training," by James M. Dodge, President.

This paper caused much pain to some of our friends of the schools and colleges who regard the use of the term "money value" in connection with education as indicating a sordid tendency on the part of those of us who agree with the author that "money value" is one test of efficiency.

> Up to a very recent date, the Apprentice System and that of Independent Delving represented the sole methods of acquiring training. . . . The blending of these two methods developed the earlier mechanical engineers and, will, even in the future, enable those sufficiently gifted by Nature and habit to acquire eminence. The progress of the world, however, calls for a better and more speedy means of producing trained men than could ever be developed by the methods of self-instruction. . . .
>
> We are all prone to take extreme cases of success or failure as the basis of our opinions, and lose sight of the fact that it is the average man whose career shows the true force and direction of the current.

Annual Meeting, 1904. "Some Refinements of Mechanical Science," by Ambrose Swasey, President. Closing paragraph:

> We have recounted some steps of the progress that has been made in the measurement of time, of angles and of length, together with some of the refinements in these measurements, but we are confronted with the fact that notwithstanding all that had been accomplished from centuries past down to the present time, there are, as never before, many imperfections requiring new problems in mechanical science to be worked out for the further enlightenment and welfare of mankind.

Annual Meeting, 1905. "On the Safe-Guarding of Life in Theatres: A Study from the Standpoint of the Engineer," by John R. Freeman, President. A document based upon patient, competent study. A statement of actual conditions found and of proposed remedies.

> In the course of my own studies of the theatre and auditorium problem, I have seen almost everywhere conditions affecting the safety of life that would not be tolerated by the managers of our best industrial works, and all from simple failure to know or to give attention.

Annual Meeting, 1906. "On the Art of Cutting Metals," by Frederick W. Taylor, President. An illustrated book of 248 pages, or 319 pages including the discussion, covering the result of 25 years of work, concurrent work of educated engineers and workingmen, and continuous coöperation of ten great industrial establishments, at an expense of $200,000. A rare example of persistent investigation for the development of truth.

Answering parts of the discussion, Mr. Taylor says:

> Our interest in the scientific, or what one might call the intellectual element of the art of cutting metals has been, of course, very great; but after all the true measure of the value of this work should be the actual every day help which will be given by these laws to the superintendents, foremen and mechanics in our machine shops.

Annual Meeting, 1907. "The Mechanical Engineer and the Function of the Engineering Society," by F. R. Hutton, President. An exhaustive presentation of the two subjects covered in the title.

Tredgold's definition of engineering "is silent upon that group of engineers concerned with the liberation, the generation and transmission of forces which are potential and are not realized in nature until in accordance with the natural laws some engineer has caused them to appear."

The author points out that while Tredgold did not include them in the "powers of nature," today there must be included "the forces which are economic or social or psychological in their application" when "human beings become the organs and implements of the factory as a tool of production. . .

> The Engineer has therefore become an economic factor as he was not conceived to be in that earlier day.

. . . .

> Any policy or step which gives occasion rightly to charge a tendency for a national body to localize, is an invasion of opportunity and value.

The author considers at length and favorably the reasons for encouraging local meetings of sections of the Society. Such sections may be either territorially grouped, or by topics and common interests."

> Is the privilege of service and of function all on one side or has the Society the right to ask from its members a reciprocal duty to itself? The latter, no doubt.

Annual Meeting, 1908. "The Conservation Idea as applied to The American Society of Mechanical Engineers," by M. L. Holman, President.

The author uses as his text the Conservation Congress held in 1908 at the White House, presided over by the President of the United States and attended by the Governors of States and representatives of engineering and other organizations. An admirable example of the engineer as a citizen employing his special knowledge for the instruction of the community.

During the discussions it became apparent that some effort would be required to keep the conference from political bias. . . .

The President particularly desired the coöperation in the movement of the engineers of the United States and subsequently ascribed to the action of the Engineering Societies the credit of inaugurating the conservation campaign on non-political lines. . . .

As new parties are developed the chances of government by the minority become greater, and with a sufficient number of political parties in the field, revolutions will be the order of the day. . . .

One city for years discharged its sewage into the margin of a lake and took its water supply from the same place. . . .

With us, however, civil and religious liberty seems to include unnecessary exposure to disease. At the conference in Washington, the preventable disease problem was practically overlooked, perhaps from the fact that no trust seems to be operating in that field. . . .

I venture to suggest that we might make progress by ascertaining the secret of German frugality and prosperity rather than by compiling masses of figures to prove what is well known, viz.: that we are wasting the resources of Nature like a true prodigal son. . . .

Which one of you, as householder or engineer, will put up with a poor run of coal in order that posterity may have a good coal? The departments of our government demand the best grade and are not willing to take the "run of the mine."

There is, at present, a strong tendency towards bureaucratic development that is inimical to the successful continuity of our form of government. . . .

Concludes: The Engineering Societies must fall in with the conservation idea and see to it that the returns from the Societies are commensurate with the efforts expended in operating them.

Annual Meeting, 1909. "The Profession of Engineering," by Jesse M. Smith, President. First historical and then largely a consideration of Society activities and the interrelationship of the several engineering societies.

The Engineer capable of being at the head of the larger engineering works must know something of many things, several things well and one thing profoundly.

Concludes: The American Society of Mechanical Engineers has before it a future of usefulness to its members and influence in the profession, which is unlimited. It only requires that we stand by our tradition of increasing the membership with men of high quality as Engineers; that the members maintain enthusiastic devotion to good professional work; that they cooperate with each other in the broadest and most friendly spirit to produce that solidarity of membership and devotion to high ideals, which will compel the world to class the profession of Engineering with the other learned professions.

Annual Meeting, 1910. Address without title, by George Westinghouse, President.

After a brief reference to the affairs of the Society, and particularly to the Joint Meeting at Birmingham, England, with the Institution of Mechanical Engineers, and a brief discussion of "the standardization of mechanical devices," in compliance with suggestions made to him, the author devotes the remainder of his address to an "authoritative statement for the records of the Society" of "my work in developing the airbrake." A valuable record of a great work.

Annual Meeting, 1911. "The Engineer and the Future," by E. D. Meier, President.

> A century ago the distinction between the civil and military engineer sufficed, but a few decades ago it became necessary to differentiate in turn the mechanical and electrical engineer, while quite recently upwards of a hundred specialties were enumerated in the attempt to define the activities of the profession, each of which has its recognized experts. . . .
>
> Speaking of men of science: It is the duty, the glorious privilege of the Engineer to receive their discoveries with reverent hands, and apply them to the solution of the practical problems of life. . . .
>
> The Engineer then is a devout believer in natural laws. He knows that they are immutable and permit no exceptions. He needs no Supreme Court to define them as reasonable. . . .
>
> The Engineer is responsible for the vast increase in appliances to meet every demand of that most voracious of living beings, man. The mass of mankind needs to be educated to understand and use them properly. He is in honor bound to supply this education.

As we read these papers continuously, we must be impressed with the wide scope of our professional responsibility, and we, more particularly as mechanical engineers, must be impressed with the point so strongly made in the address of Holley, and referred to by many of his successors, that mechanical engineering underlies all engineering. But here it is well for us to keep in mind that all engineering, while differentiating in great variety as to details, necessarily must be considered comprehensively in the planning of nearly all important undertakings.

The words of our past-presidents serve continually to remind us that the responsible engineer must be a completely qualified expert in some one branch of engineering while possessing a broad grasp on engineering activities as a whole, including the ethical and sociological elements of industrial administration.

Especially for the benefit of students in engineering, I suggest that these addresses be gathered together in a separate volume. A thoughtful reading of these papers should serve to teach these students that the profession they are preparing to enter is committed to public service along broad lines of usefulness. I further suggest, in future lists of past-presidents that Alexander L. Holley's name be included as the Chairman of the preliminary meeting for organization. We may readily believe that he would have been elected to the office of President if he had not been on the first nominating committee, and if it had not been for his untimely death less than two years after the Society was organized.

As we look over the actual record of progress since the writing of the earlier of these papers, we find that the growth and improvement in material things in many cases has surpassed the prophecies of the writers; but in educational and sociological questions, and particularly as to the relations between capital and labor, so-called, I fear the hopes expressed have not been realized. Here then are the opportunities for the men who, if they will, can speak with authority.

In one other particular we must be strongly impressed by the reading of these papers—the great educational value of the study of the history of engineering. To the engineer-student and the young engineer especially, this study is of great value both specifically and culturally. It is a branch of our educational work more or less neglected in many of our colleges of engineering. Those of us who came more directly in contact with Mr. Conrad Matchoss, the representative of the Munich Museum, during his recent visit to the United States, must have realized that here we have opportunities for progress. And intimately connected with this teaching of the history of engineering is the need for the establishment of at least one comprehensive museum, illustrative of industrial progress, organized somewhat along the lines of the Munich Museum. Let us hope that there may be found, and soon found, those willing and able to father such a scheme. It is a hopeful sign that several of the national engineering societies and other interests are preparing to coöperate for the solving of this problem.

The question of the responsibility of the engineer must carry back to those who are responsible for his education and specific training; including not only the colleges of engineering, but also the graded schools and the employers and others in control of those employed.

With regard to the schools in which our boys are prepared for the engineering college or for a direct entry into business or industrial life, may we not charge that these schools are not as a rule conducted for the benefit of the masses? May we not claim that the public schools, supported by taxation, should be administered primarily for the preparing of the masses for self-support? The keynote in our scheme of public education should be thoroughness, and particularly with regard to the three Rs and the elementary studies in general. The course of instruction in our public schools should be shaped for the benefit of those who are *not* to enter college; that is, for those who, by one cause or another, are forced to become wage-earners at eighteen years of age *or less*. In the scheme, adequate provision should be made for those who do not and cannot remain in school beyond the grammar school period. This change would not work an injustice to those who find themselves in a position to continue their book- and laboratory-study in the colleges. The present scheme tends strongly towards superficiality, which must be harmful to all.

In the case of those who are preparing to enter the college of engineering, I hold that they should not be subjected to a specialized preparatory training. I hold that these boys particularly should receive a sound general training, for they are the ones who will obtain later the advantages of the specialized training. The high-school pupils who are not to enter the college of engineering are the ones more in need of instruction in mechanical drawing, manual training, and the like. If, in the allotted time, the boys preparing for the college of engineering could get a sound preparation in the general studies and also get the preliminary practical training, so much the better. But the crowded curriculum of the present day tends to prevent this. *To secure thoroughness our public schools must reduce their requirements or increase their efficiency, or both.* And in this connection it must be realized that all culture is not obtained from so-called cultural studies.

Of late years we hear much to the effect that, by reason of the rapid strides made and being made in engineering science, the courses in our colleges of engineering should be extended from four years to five, six, and even seven years. Included in this scheme of extension is the purpose to devote a considerable portion of the college course to the general or non-technical studies. If this is wise, then why not use the years of preparation most advantageously on the general studies? In the case of the boy preparing for the college of engineering, why begin to specialize before he enters college? The case of the boy who is to go out from the grammar school or high school to become a wage-earner is quite different. We might, if it is practicable, specialize in his case. And here the coöperative system, the alternating of school and shop, or school and business, demands our thoughtful and sympathetic consideration. This same system, carried on a higher plane, is particularly worthy of our professional attention, especially as now being tried so intelligently under Dean Schneider, of the College of Engineering of the University of Cincinnati. In any case, in the four years engineering course, the general studies should not be slighted and the technical studies should be so presented and taught as to give them the greatest possible cultural value.

For the great majority of students, I cannot believe that it is the part of wisdom to extend the college engineering course beyond the four years which is now the general rule. For these men the age of graduation, on the average, is about twenty-two years. At that age a young man intended for our profession certainly should be prepared to earn a living; continuing, however, to be a student, as he must continue to be to his last active day in his profession, if he aims to fill a position of authority.

If the college course is to be extended by reason of the many more things now to be learned, will five, six, seven, ten, or even twenty years be sufficient? My answer is in the negative, and for two reasons. No matter how many years the student remained in college there would be more to learn of engineering science; and much that the engineer needs to know, the college or university cannot teach. But in four years the college of engineering should be able to teach its students, if they have the natural qualifications and have been soundly prepared, how to learn by themselves, and so how to profit effectively by the teachings of experience. Is there not some measure of disadvantage in keeping an engineering student engaged exclusively on the study of theory, even if the theory is presented in as practical form as is possible in the class-room and laboratory? Is it not true that those who employ young engineers who have had only four years of college environment complain that too many of them are at first more or less disqualified for practical work by having too high an appreciation of, and too great a reliance upon, their college training? The longer they stay in college, the more apparent will be this partial disqualification.

I know that I shall here be misunderstood to the effect that I am arguing against college training for the engineer. Nothing could be farther from the truth. I am arguing in favor of a proper balance between the teaching of the college and the teaching of the school of experience; that is, a proper balance between theory and practice.

Also, I am not arguing against post-graduate courses for the few who may be specially qualified for advanced study in theory and research. Though here I believe that many engage in college post-graduate study who would do better out in the field of practice. A man is not temperamentally qualified for research simply because he thinks he is. The best graduate school for the great majority of engineer graduates is the school of experience. In many cases even research can be more advantageously pursued outside the environment of the college, in direct contact with the conditions governing practice. This is shown in the many instances of the fruits of outside research carried back into the college and there taught to the undergraduates, giving them the data so disclosed and helping to impress upon them the value of and necessity for experience teaching. Why is it, in the face of these facts continually presented to the college instructors, that certain of them are so ready to claim a monopoly of all educational agencies?

It can be claimed that the store of experience teaching thus carried back to the college can there best be classified and standardized. To a large extent this is true. But here, as in every other such question, there are two sides to be considered. Not always is the schoolman qualified to interpret correctly and comprehensively the data thus placed in his hands. Here is where our engineering societies are doing an important work outside of the colleges, as well as in coöperation with them and their professors as individuals. In the cause of increased efficiency this all speaks for coöperation, and particularly for an adequate appreciation of the value of coöperation between schoolmen and practising engineers. To this end the professors of engineering should be encouraged to engage in practice for their own benefit and for the benefit of their students. This coöperation can be further developed by direct interchange of ideas and data between professors and their *former students*, as practised in some measure in this country, and to a much greater extent, I understand, in some of the German universities.

Are not many of our troubles with respect to education occasioned by the belief on the part of many educators that all education is to be obtained only within the school and college walls? If they do not believe this, do not many of them minimize the educational value of experience in the business world in contact and competition with one's fellows? Having in mind some of the men with whom we are constantly associating, it seems absurd to have to remind ourselves that the school of experience teaches many things which the school and college cannot teach, and that this school of experience also may exert a strong cultural influence.

Even if some of the schoolmen are inclined to underestimate the educational value of experience teaching, we as engineers must not forget, before the first college of engineering was organized, that the engineer was busy at his many tasks, and the mechanical engineer had produced the steam engine,—that most potent progress-maker of the ages.

While referring to experience teaching and the insufficiency of the unsupported college training for the engineer, permit me to give a word of advice to the juniors of our profession. Too frequently young engineer graduates assume the responsibility of acting as consulting engineers before they have had adequate practical experience. A few make the more serious mistake of assuming this great responsibility immediately after graduation, before they have had any practice. The engineer graduate is not an engineer until he is qualified to deal with the practical conditions of his selected specialty. He must be a commercial engineer in the sense that he should regard the money, for the investment of which he is more or less responsible, as a sacred trust. It is not for him to risk his employer's money in experiments for which he is not qualified by specific experience.

Still more unfortunately some of these young men set up as general consulting engineers. The saving clause is that they are probably as competent in one engineering specialty as another.

No man should attempt the role of consulting engineer until he has had a comprehensive and practical experience in his specialty. By doing so the offender brings discredit not only upon himself but upon our profession as a whole.

Having said this to the young graduate, permit me to say a word as to the responsibility of his employer. The young graduate should not be left without guidance in the school of experience. If the employer is an engineer or is competent to direct in the practical things of his specialty, he should see to it that the employee gets every possible opportunity to learn the practical side of the business and to harmonize the theoretical with the practical. Too often the cadet engineer will be difficult to teach and direct because of his unreadiness to believe that he needs this practical experience. Too often he is unwilling to get down to the long hours, dirt, and drudgery which may be required to win this practical experience. It is the duty of the employer to provide the means for this, and, failing in success after a fair, patient, and intelligent trial, to assist the youngster to a better understanding of what is required of the engineer by giving him his discharge. I know of a number of good men who have been saved by this seemingly severe treatment.

In the treatment of the cadet engineer there rests upon the employer a grave responsibilty. Many a young fellow has been unfairly treated because through ignorance, indifference, or stupidity the one in authority has expected more than could in reason be demanded. Some employers, not technical graduates themselves, exaggerate the immediate results to be obtained from a college training. Others, college graduates themselves, forget how little they knew of practical things when they graduated, and they think they are comparing the ignorance of the cadet with what they knew when they graduated; whereas, really they are comparing with what they know now after ten, twenty, or thirty years of practical experience.

Other cadets have the misfortune to fall under the control of so-called " practical men " who despise " book-learning " and are glad of an opportunity to expose the ignorance of the " college boy." It is the duty of the employer, especially if he is an engineer, to see that the young graduates taken into his employ are, as far as possible, saved from these harmful influences, including the conceit of the graduate himself, which work injury to both employer and employed.

From all that I have said as to the opportunities for improvement, let it not be understood that I am condemning the combination of educational agencies which has produced the men who have done so much for this country through its industries. We must realize that the passage of time has wrought of late great changes, not only as to the science of engineering, but in a marked degree as to the sociologic and economic conditions within which we must practice, if we are to meet our responsibilities to both capital and labor. A system which *permits* men of more than average ability or determination to qualify for our profession should be so improved through experience teaching as to enable us to turn out from our educational mills a larger percentage of first-class product and to reduce the percentage of rejections. Many a young man who might have given a good account of himself, if he had been better handled at some turning point in his career in college or practice, has failed because he had not yet developed the stamina to resist the forces, negative and positive, which were opposing his progress. It is a source of gratification to me that I have saved some from breaking under the strain of injustice in the college and in the school of experience; and it is a source of regret and humiliation to me that in certain cases, as I can now realize, I failed in my duty in this respect.

In arguing for saner and better balanced educational methods to meet the conditions referred to, conditions of the past as well as of the present, I have no sympathy with those who condemn all our educational theories and methods as obsolete and therefore to be consigned to the scrap heap. Some English engineer, whose name I have forgotten, said that where the United States engineers and industrial managers had a distinct advantage over his countrymen was in their readiness to scrap obsolete apparatus. This " scrapping " process can be, like everything else, carried to extremes. We should first determine whether by new combinations the apparently obsolete apparatus or machinery cannot again be made commercially efficient. The inefficient elements only should be replaced. And when it comes to the question of scrapping plant, we must determine whether the interest on both the old and the new does not absorb the anticipated savings. I do not hesitate to affirm that in this country, in our enthusiasm for improvement, we have frequently been guilty of wasteful practice in this regard. This, in a marked degree, applies to much that has been proposed in connection with the scrapping of our educational agencies.

In connection with discussions of industrial questions and the education of the engineer, we hear much of the opportunities for increased efficiency. There are such opportunities and there always will be. But we also hear much of conservation, frequently from the same sources. Efficiency of methods should include true conservation; the elimination of the false and defective, but certainly the retention of all that has been proved through experience to be true and useful. With Patrick Henry I say, "I know of no way of judging of the future but by the past." Many of our modern reformers would change this to read, "I know of no way of planning for the future but by disregarding the past."

With the conserving of the good and useful there should be the constant effort to render these still more useful. The older a method or practice, provided it has stood successfully the test of years, the more it is to be prized. Yet we are told by some reformers, because a thing is old, and for that reason alone, that it should be scrapped. We are told, because of the marvelous progress made in engineering science in late years, that all the teachings of our schools of engineering should be scrapped. We are told that practically all that was taught in these schools twenty-five years ago is now obsolete. Have all the teaching of languages, logic, history, mathematics, physics, and chemistry of the past been rendered valueless because we have advanced in our knowledge of Nature's laws? Apart from more direct arguments, we may say that one of the most valuable lines of instruction for the study of engineering is the history of the development of engineering science. If it is true that all this of the past is valueless, how was it that the men of the past, taught in the schools and outside of the schools, were able to produce these wonderful advances?

What is the specific function of the college of engineering? Is it to store the brain with facts, or what the teachers believe at the time to be facts, or is it to train and discipline the brains of the students to think with facility and accuracy along the lines of their future vocations? Many of us who, for the time, have forgotten much of this store of facts without being seriously embarrassed by the loss, have our answer to this question. Again let me say that the school and the college cannot complete the training of the engineer; and that these agencies can only prepare the student to learn his profession in the field of practice. Given the personality, it remains for him to develop in the field of practice the initiative for which the formal teaching and drill of the school and college should have prepared him effectively. Included in this preparation should be some teaching of the business side of engineering practice, including the principles of such subjects as accountancy, depreciation, commercial law, patent law, specifications, contracts, and analysis of data.

Whatever may be said as to the room for improvements in the agencies, processes, and methods employed in the education of the engineer, it should need no argument to demonstrate that the leaders in the profession are as a class those best qualified to advise authoritatively in connection with the efforts to solve many of the most serious problems of the day, involved as these are with questions of transportation, public utilities, and the industries in general. And for the well-being of our country these problems must be solved wisely.

This is an age of reform, and of late years reforms have been so hastily and incompetently put forward as to bring the term reform into reproach. In fact, a significant feature of many of our reform movements is the readiness of the leaders to act on impulse and without anything approaching adequate investigation. As has been well said, it seems to be a characteristic of this class of reformers to go too far and too fast.

It is with deep regret that I express the belief that college professors, especially professors of economics, and even ministers of the gospel have frequently been offenders in this regard. I believe that certain professors are being retained in their chairs who should be displaced. Especially in the case of universities this may be due to a tendency on the part of president and trustees to exaggerate the right of free speech. Certainly a professor in a State university, to say nothing of the endowed universities, should not be permitted to teach doctrines subversive of law and order and the rights of the individual and property under the Constitution. If these men cannot be controlled by those to whom they are immediately responsible, they should be controlled by those who control the universities.

It is to be borne in mind constantly that good intentions do not qualify one to do expert work, whether that work be in connection with some reform measure or in some other line of public activity. Here is to be found a grave error of which many an honest enthusiast is guilty. The more astute and sordid of the politicians welcome the assistance which they can secure by guiding the enthusiastic and hysterical reformers into lines of activity which will offer opportunities for trading in immunity, obtaining fees for lobbying, or securing remunerative employment as the agents of these enthusiasts.

Righteous indignation is to be welcomed, and we had better start out in our reforms with the conviction that *as long as the world exists* there will be full opportunity for righteous indignation. But righteous indignation does not of itself provide a remedy for the evils at which we rebel; it only supplies the desire, and possibly the purpose, to produce a remedy. Righteous indignation and misdirected zeal may produce conditions practically as bad as those which it was purposed to correct or eliminate. Reform should not depend upon hysterical suggestion and fitful support, but should be actuated and maintained by all the forces suggested by experience; it should be constantly and tenaciously, but not vindictively, pursued, acting along the best lines suggested by competent, sane, impartial investigation.

As one of the forces to be reckoned with, and particularly in the industries in which our profession is so vitally interested and for which we must carry such a burden of responsibility, is the tremendous force of ignorance and prejudice constantly being swept in upon us by the tide of immigration. If we hold that our country is to be a haven for the ignorant and oppressed, it is then our duty to provide for the control of the elements of danger we so accept. If we offer a haven to these people so ignorant of our fundamental laws for the protection of life and property, certainly we have the right and it is our duty to demand that at least they shall be subject to those laws. The laws as they stand must bind them as they bind us until amended according to law.

The record of recent happenings shows us that there are very real dangers to be apprehended from this source. We need only to read the reports of the trial at Indianapolis of the men of influence under indictment for dynamite outrages, the record of the Los Angeles dynamite outrage so closely linked with this Indianapolis trial, the trial recently ended at Lawrence of men of like influence indicted for murder through suggestion, the trial of the man who attempted recently to kill an ex-president of the United States, the trials of members of the police force and gangsters of this city, and many other like events indicating a confidently bold disregard for the rights and the very lives of those opposed to these enemies of law and order, to convince us that popular government is under trial as it never has been before in our history as a people.

As I have before suggested, the danger does not lie alone with the ignorant and the designing; if that were true, the danger might be met with greater confidence. But we have to see that the enthusiasm of honest but misguided reformers has to be reckoned with; and these people are to be found in our schools, colleges, universities, industrial establishments, and counting houses.

Let me quote the words of Schrank who tried recently to assassinate Ex-President Roosevelt:

> The shot in Milwaukee, which created an echo in all parts of the world, was not a shot at an Ex-President, not a shot at the candidate of a so-called Progressive party, not a shot to influence the pending election, not a shot to gain for me notoriety; no, it was simply to once and forever establish the fact that any man who hereafter aspires to a third presidential term will do so at the risk of his life. If I cannot defend tradition, if I cannot defend the country in case of war, you may as well send every patriot to prison.

This is high-sounding and has a truly familiar ring. Two of the men on trial at Lawrence made statements which also indicated that they considered themselves champions of the defenceless and apostles of liberty rather than of anarchy. These appeals to unreason have a strong influence upon those who are at once ignorant and highly emotional. Unfortunately, those who cannot be charged with ignorance in the ordinary sense are led astray by these hysterical appeals to unreason because they appear to reflect a worthy motive.

And yet this man Schrank, who considers himself a hero and martyr, and who is able to put his dangerous views thus plainly and strikingly before us, by the unanimous verdict of a number of competent physicians, has been declared to be a homicidal maniac.

With the conditions at present surrounding us, which I have barely suggested, is it not of the first importance that our public school system should be kept free from teachings which are dangerous to our commonwealth? Should not the system go farther and exercise a positive influence for sane thinking upon the children under its influence during the most impressionable period of their lives? Not only should these pupils be taught directly respect for the rights of others and respect for constitutional government, but, above all, the aims and methods should be so amended that the thought constantly kept in the minds of teachers and pupils shall be that the pupils are being trained to become self-supporting and so self-respecting units of the body politic. This implies that these boys and girls shall be taught, shall have pressed home upon them constantly, directly and indirectly, that labor of the hands as well as of the brain, if conscientiously performed, is honorable. Undoubtedly, there are many schools in the land where high-minded, sane teachers are doing their best so to influence their pupils. Of this my talks with many of them convince me; but I have been at the same time convinced that most of these faithful servants of the people feel that they are working under the disadvantages of a system which too generally fails to dignify the labor required for self-support and to cultivate pride in all work well performed.

A respect for law and order should be inculcated in our public schools by the maintenance of a more intelligent and more exacting discipline. The State has a right to demand and should demand, if a free education is provided for the youth of the country, that those so benefited shall render prompt and exact obedience to those in authority. In many cases politics comes in to fetter those who are in immediate authority, and this to the great injury of the pupil, the teacher, and the community. Many men and women, now parasites upon society or criminals, would be self-respecting members of the community if they had been trained to respect honest labor and at least directed to, and given a fundamental preparation for, some vocation.

Let the public schools be conducted for the benefit of the masses and not for the benefit of the very few. The many can be provided for readily and effectively without sacrificing or even hindering those who are qualified by natural endowment to enter college. If some who now go to college were discouraged from so doing, it would be no loss to them or to the community.

Upon us as members of the profession of engineering, individually and collectively, rests the responsibility for doing our utmost to check and correct the evils which I have thus inadequately brought back to your attention. Collectively, and particularly as members of this Society, we are responsible because some members of our profession have been at fault as the advocates of hasty and ill-considered measures of so-called reform. Reforms, especially in connection with industrial administration and the relations between capital and labor, which might be inaugurated by our Society or its members after full and candid discussion, should be of decided benefit to the community as well as to our profession.

Certainly in the matters connected with public education our profession should be able to advise and direct, for the members of the profession have unsurpassed opportunities to judge of the effectiveness of the work of the schools by the results as evidenced in the product. I am quite aware that some professional educators will not be slow to charge that the engineer is not an expert in the field of education, but to this we may reply that this is not solely an academic question and the results are showing every day that the educators need the coöperation of all who are qualified to assist. And may we not claim that the members of our profession as a class are brought as close to the hearts of the people as are the workers in any other one vocation?

Here is another opportunity for unselfish, open-minded coöperation, which is so much needed in our country today.

Now let us for a moment review the work of our Society during the year just closing. The record will be placed before you in detail, but I wish to meet the question, Are we progressing? Are we, in some fair measure, meeting our responsibilities?

In membership we have made a net increase from 4007 to 4350, not counting the affiliates of the Gas Power Section, which show a net decrease of 8, and the student affiliates, which show an increase of from 635 to 722. It is of interest here to note that since Past-President Jesse M. Smith made his presidential address in 1909, the membership of the four national societies generally considered together, civil, mining, mechanical and electrical, has increased from 19,000 to 22,800. The many other engineering societies, specialized and local, no doubt would bring the combined membership up to not less than 50,000.

Our Society may look for a much larger increase in membership during the coming year, as a result of the earnest and intelligent work of the Committee on Increase of Membership under the able and enthusiastic direction of Past-Manager I. E. Moultrop. If the proposed amendments are approved, the additional grade of Associate-Member should serve to bring into our Society a considerable number of men capable of broadening our sphere of usefulness. Not only should we do our utmost to interest as large a proportion of the membership in our activities, but we should do all that is proper to bring into our Society those who are eligible under any of the several classes of membership and who are willing to aid in our work, remembering that membership in such a society as this means giving as well as receiving. This broadening of scope of membership is, as I have already shown, in accord with the suggestion made by Alex. L. Holley at the preliminary meeting in 1880.

Chiefly to the work of the Committee on Increase of Membership and the Gas Power Section may be credited the $10,000 received this year from initiation fees and $20,000 added to our annual income. This activity has materially helped us financially, so that after meeting our pledge to pay off our land bonds, at the rate of $6000 a year, we have added $4000 to our surplus.

Under the able direction of our Publication Committee and the staff, not only has The Journal reflected great credit upon all concerned, but it has contributed a net surplus of $2000 to our treasury. This can be compared with an annual deficit of about $10,000 earlier in our history.

The excellent showing with regard to our finances in general is in large measure due to the supervision of the Finance Committee under the untiring and devoted direction of the Chairman, R. M. Dixon.

Mention is due for the most efficient management of the United Engineering Library under the committee, librarian and staff. This library is performing a service to the engineering profession which is not equalled in our country and of which the three responsible societies may well be proud.

A Society such as ours, if it is to grow in usefulness and influence, must not depend upon the activities of the officers and committees, no matter how devoted and self-sacrificing. The policy of the Society should be to engage the membership at large in its activities to the greatest degree possible. With this reflection in mind it is most gratifying to note that we have made decided progress during the year in organizing additional geographical groups, and in making some progress towards the development of a simple scheme of administration therefor which shall provide as large a measure of home rule as is consistent with our constitutional requirements.

Also, during the year most satisfactory progress has been made in organizing sub-committees of the Committee on Meetings under the chairmanship of Dr. C. E. Lucke. There has been suggested forty sub-committees to cover as many phases of mechanical engineering as found in the industries of the country. Believing it is wiser to make haste slowly, the full number of these committees has not yet been appointed. The following have been appointed and have organized: Textiles, Administration, Cement Manufacture, Iron and Steel, Air Machinery, Railroads, Hoisting and Conveying, Industrial Building, Fire Protection, Machine Shop Practice.

The work of these sub-committees may be expected to extend materially the usefulness and influence of our Society. The other sub-committees as suggested should be organized just as soon as a sufficient number of specialists can be interested and the money can be found.

Primarily, I believe, due to the initiative of our Secretary, Calvin W. Rice, the engineers of America and Great Britain have coöperated to erect a memorial window in Westminster Abbey to Lord Kelvin. Members of our Society participated liberally in this tribute to a great man and a great scientist.

Your Council has accepted an invitation to participate in a meeting of the Society of German Engineers to be held in Leipzig next summer. It is to be hoped that our members will evidence their appreciation of the attractive program, which our hosts have prepared, by attending in large numbers.

It is proposed that in connection with the San Francisco Exposition in 1915 there shall be an International Congress of Engineering. In concert with the Society of Civil Engineers, the Institute of Mining Engineers, the Institute of Electrical Engineers, the Marine Engineers and Naval Architects, your Council has already taken preliminary action favorable to this undertaking.

A number of most important committee reports, covering technical subjects of vital interest, will be presented during our meeting. Special reference may be made to a notable report prepared by Mr. Geo. A. Barrus as a member of the Committee on Power Tests.

To provide for the whole of the rich program prepared by the Committee on Meetings, our professional sessions will have to be divided into a number of sections.

Even this brief and fragmentary reference to the work of the year serves to show that the Society, acting through its officers, standing committees, special committees, and the staff, has been maintaining its reputation for effective service and has been reaching out into other fields of usefulness. It is for the members at large to appreciate the service thus rendered and to be prompt to do their share by accepting the opportunities for service offered by membership on the committees, present and prospective.

Thus at considerable length, and yet inadequately, I have discussed the opportunities and consequent responsibilities of the engineer of today. If we claim, as we should, to be members of a profession, we must accept the responsibilities involved. We cannot claim that our profession is one of the three learned professions, because the ignorance of the past created a limitation in favor of religion, law, and medicine. But we can claim that though much of that which the engineer must have at his command is not to be learned from books, it by no means follows that his education is therefore less "liberal" than that of the minister, lawyer, or physician.

There appears to have been a tendency, not so apparent at present, to deny to the mechanical engineer the professional position more readily conceded to the civil or mining engineer. This seems unreasonable and indefensible when we study the question and are forced to endorse Holley's claim that mechanical engineering underlies all engineering. The reason for this rather intangible discrimination is in part due, I believe, to the fact that so many of the rank and file of our branch of engineering are engaged in working out the details, more or less important, of undertakings which are under the general direction of civil or mining engineers or others not members of our profession. Many mechanical engineers thus become absorbed in the invention and development of mechanical devices, possibly of vital importance in the general scheme, and so fail to obtain a grasp on the undertaking as a whole.

The question of precedence need not be raised; there is credit enough for all. As engineers we are committed to the doctrine of efficiency. Efficiency must come from coöperation, not from discussions as to precedence and relative dignity.

Watt's steam engine made Cort's rolling mill possible. Cort's rolling mill opened up to Watt's engine a new sphere of usefulness.

The Panama Canal, under the direction of thoroughly capable engineers, was a failure until the bacteriologist, the physician, and the sanitarian made it possible for white men to live in the fever stricken zone. Now, while under the general direction and control of military and civil engineers, the success of the undertaking largely depends upon the mechanical and electrical engineers.

Then, while confidently asserting our claim to membership among the liberal professions, and accepting to the full the responsibilities which are thereby involved, let us be prompt to recognize that the progress of the world, material and ethical, depends upon the unselfish, intelligent, and devoted coöperation in service of all professions and vocations under the leadership of men of vision, intellect, power, and humanity.

FACTORS IN THE SELECTION OF LOCOMOTIVES IN RELATION TO THE ECONOMICS OF RAILWAY OPERATION

By O. S. Beyer, Jr.

ABSTRACT OF PAPER

- Introductory remarks; the subdivision of the problem
- Consideration, in the selection of locomotives, of:
  - The service
  - The nature of the business
  - Topography, train speeds, and train resistance.
- Sizes and types of locomotives available:
  - Passenger locomotives
  - Freight locomotives
  - Switch locomotives
- The permanent plant and its relation to the selection of locomotives:
  - Track and bridges
  - Yards and passing sidings
  - Locomotive terminals
  - Shop facilities
  - Clearances
- The relation of operating expenses to the selection of locomotives:
  - Items affected, summary
  - Fuel
  - Water
  - Lubrication
  - Supplies
  - Enginehouse expenses
  - Train supplies and expenses
  - Wages of enginemen
  - Wages of trainmen
  - Locomotive repairs
  - Freight train car repairs
  - Maintenance of track bridges and buildings
  - Overhead charges
- Final determination of most economical locomotive to select
- Summary

FACTORS IN THE SELECTION OF LOCOMOTIVES IN RELATION TO THE ECONOMICS OF RAILWAY OPERATION

By O. S. Beyer, Jr., Chicago, Ill.[1]

Non-Member

The problem of locomotive design is comparatively simple when it is clearly known what is desired. The possibility of effecting operating results by the introduction of improved locomotives alone, or by their use in connection with such changes as grade revision, is not as fully appreciated as it ought to be. To make an intelligent selection of motive power for a railroad, it is necessary to study the effect which various types and sizes of locomotives will have on operating expenses and fixed charges. Statistics published by the Interstate Commerce Commission covering the entire railroad field of the United States show that 55 per cent of the operating expenses are affected more or less directly by the motive power.

2 The wide range of motive power now available will have to be considered in future double track and relocation work, grade reduction, elimination of rise and fall, and curvature and distance, in order to effect the greatest economy possible for the capital expended. It should no longer be necessary when relocating a division to increase its capacity and reduce operating expenses, to go to extremely heavy capital expenditures to reduce grades to the minimum of 0.2 or 0.3 per cent., as it is usually much cheaper to provide locomotives of greater power.

3 The main steps in the careful selection of motive power may be divided into the consideration and study of:

a the service
b the nature of the business

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[1] Care of 2d Vice-Pres. Rock Island Lines, La Salle St. Sta.

The American Society of Mechanical Engineers, 29 West 39th Street New York. All papers are subject to revision.

c the topography of the road, train speed and train resistances
d the types and sizes of locomotives available
e improvements to the permanent plant
f effect of various types and sizes of locomotives on operating expenses
g final selection of most economical type and size of locomotive

THE SERVICE

4 Motive power is used in three general classes of service, namely, passenger, freight, and switching.

5 Passenger service may be further subdivided into the following classes: High speed or through service, and suburban or local service.

6 Freight service may be subdivided into slow or drag service, fast freight service, and pusher service.

7 Consideration of the service will determine whether the engines are to be built suitable for just one class or for a combination of classes, such, for instance, as switch and helper service, slow and fast freight service, freight and helper service, or passenger and freight service. This goes hand in hand with the consideration of some of the other features, notably the amount of and the different kinds of business, the size and types of engines available, and the effect of the engines under consideration on operating expenses.

NATURE OF THE BUSINESS

8 The special nature of the business, while intimately related to the general service for which the engines are intended, deserves some particular consideration. Through passenger service, for instance, may vary between long distance high-speed hauls, and slow speed frequent stops hauls. Freight service, especially, may vary between hauling almost exclusively trains of low class bulk commodities, such as coal and iron ore, which generally move in well built high capacity steel cars at slow speeds, and hauling trains of a decidedly mixed nature, loads and empties, box, furniture, flat, automobile, gondola and stock cars, which are not of high carrying capacity and are seldom fully loaded, resulting in trains of great length when any large amounts of tonnage are hauled. Due to the generally inferior

construction of cars which compose a mixed train, the weakness of the draft rigging of the older cars, the limitations of the older types of air-brake equipment, and the tendency to long trains when heavy tonnage is handled on railroads where this class of business is general, the motive power problem assumes an aspect entirely different from that on roads where the business is of the nature first mentioned.

9 In switching service the demand may vary between straight yard work and hump work, and in pusher service it may vary between passenger pusher and freight pusher work.

TOPOGRAPHY, TRAIN SPEED AND TRAIN RESISTANCE

10 The consideration of the topography, train speeds, and train resistance of the territory in which the new engines are to operate will at this time only take recognition of hauling capacities and train lengths. The extensive research work recently conducted by many eminent investigators, railroads, and locomotives builders furnishes reliable information and data from which to determine very exactly what the hauling capacities of different types and sizes of locomotives are, and the speeds and resistances of the trains which can be hauled by them.

11 The hauling capacity at different speeds depends on the sustained tractive effort, which in turn depends upon the boiler capacity and the engine efficiency. Locomotives intended for high-speed service should have high sustained tractive efforts. Locomotives for heavy drag and switching service should have high tractive efforts at slow speeds, and may sacrifice high sustained tractive efforts at high speeds in order to attain this end. When selecting locomotives to meet certain conditions in regard to train weights, train speeds and opposing grades, it is necessary to analyze the situation from this standpoint.

12 *Passenger Engines.* Grades, speeds, and train resistances must be very thoroughly considered when new passenger engines are to be purchased. Passenger engines are intended for high-speed work. Modern operating conditions frequently present cases of heavy trains composed of all steel cars. The weight of passenger cars, due to the desirability of greater passenger carrying capacity and heavier construction, is rapidly increasing. Hence, the most essential quality to be provided in a passenger engine is the ability to maintain large sustained

tractive efforts at high speeds, as well as high starting efforts at low speeds. This ability of a passenger engine is secured by providing ample boiler capacity and good steam engine efficiency. The ability of a passenger engine to accelerate rapidly is another quality which must be considered, particularly if the engine is to be engaged in service in which stops are frequent. The power required for high rates of acceleration, especially on grades, with heavy passenger trains is enormous. Since the locomotive power available is limited principally by the steaming capacity of the boiler, the larger this steaming capacity the sooner will the engine be enabled to reach its maximum speed.

13 *Freight Engines.* Freight and pusher engines are engaged in a service which requires at the critical time very high tractive efforts at slow speeds. This depends to a large extent upon the weight placed on the drivers and the total weight of such engines must thus be so distributed that a relatively large weight falls on the drivers. With the cylinder and driver dimensions and the boiler pressure so arranged that the maximum tractive effort at the rim of the drivers equals 22 to 25 per cent of the weight on the drivers, a satisfactory combination for an engine for ordinary freight service is secured.

14 Modern conditions demand an increase in fast freight service and relatively large sustained tractive efforts at high speeds over heavy grades are becoming more necessary than ever. Locomotives for fast freight service only may afford to sacrifice some initial tractive effort for the sake of having recourse to a proportionately larger heating surface when great quantities of steam are necessary at high speeds. Pusher engines and road engines, on the other hand, intended exclusively for slow service may be permitted to have a large tractive effort capacity at slow speeds with a sacrifice in high sustained tractive efforts at high speeds.

15 The large majority of freight engines purchased are intended for a service which is a combination of fast freight and drag or slow freight service. Under these circumstances it is usually desirable to get as large a steaming capacity as possible consistent with a high tractive effort at low speeds. Incidentally, engines with good steaming capacities when operated with heavy tonnage trains are proportionately more econ-

omical in fuel and water consumption, as well as capable of maintaining a higher average speed over the entire division.

16 Consideration of the topography of the railroad and the hauling capacity of freight locomotives presents the problem of permissible train lengths. If the territory over which the locomotives are to operate is, to a large extent, a succession of many sags and pitches and contains several momentum grades, the continual running in and out of the slack between the cars is a serious matter and tends to limit the length of the train and the amount of tonnage per train which can be hauled. The nature of the business, whether it is ore, coal or pig iron moving in high capacity modern steel cars, or general merchandise moving in box cars, refrigerators, small capacity gondolas or other similar cars has a further bearing on this feature. The lower the average total car weights of trains the longer the trains when large amounts of tonnage per train are hauled. The introduction of high capacity friction draft gears, steel underframes, and improved air brakes are tending steadily to minimize the difficulty of operating very long trains. The perfection of the variable load brake may help further in this direction. Cases are on record where trains of 90 and even more loaded cars, each car weighing 70 tons, have been hauled with success. Trains of 125 empty cars are not unusual in daily operation. Most of these extremely long trains are running over territories whose grades are low, or which have no broken profile. Furthermore the nature of the lading hauled in these exceedingly long heavy trains, is such that, should any heavy shocks occur, the lading cannot be damaged. Cars filled with automobiles, furniture, or general merchandise or flat cars loaded with agricultural machinery are different and must be handled with greater care in shorter trains. Every district for which motive power is intended presents certain little peculiarities when advisable train lengths are considered. Experience in the operation of trains hauled by the older types of locomotives must assist in determining the final answer to this question. As a rule there are a great many circumstances, such as the capacity of the side tracks and other conditions of the permanent way, which are apt to limit the length of trains before the profile conditions establish limitations.

SIZES AND TYPES OF LOCOMOTIVES

17 *Passenger Locomotives.* The principal types of locomotives available for passenger service are the Atlantic (4-4-2) type and the Pacific (4-6-2) type. The American (4-4-0) type, the Ten-Wheel (4-6-0) type, and the Prairie (2-6-2) type have been employed to some extent, but except in unusual cases are not of special advantage. The latest development in passenger engines for severe mountain service is the Mountain (4-8-2) type. In some special cases, such as exceedingly heavy mountain service, the Mallet engine has been used.

18 The Atlantic (4-4-2) type locomotive is usually best adapted to a service in which the trains weigh about 300 to 350 tons behind the tender and the grades encountered are relatively light. Owing to its wheel arrangement it permits of a boiler of ample capacity in proportion to the cylinders. It has a short rigid wheel base and a short total wheel base. To get very high initial tractive efforts with locomotives of this type means exceptionally high axle loads, which are undesirable. Hence, when high initial and sustained tractive efforts are required for heavy trains weighing over 350 tons behind the tender and operating over heavy grades, the Pacific (4-6-2) type is usually found to be better. The wheel arrangement of this type permits a still larger boiler, greater total weight on drivers with lower average axle loads, and larger cylinders. In general, the full utilization of these features results in both higher initial and higher sustained tractive efforts, combined with better accelerative qualities.

19 For exceptionally heavy mountain service the Mountain type permits of still larger boiler capacities and greater total weights on drivers, and hence still higher tractive efforts. Several engines of this kind are in service on the Chesapeake and Ohio Railway hauling trains weighing 600 to 650 tons over grades of 70 ft. per mile at 25 to 26 miles per hour.

20 Mallet engines have been introduced to a limited extent in passenger service. The Central Pacific Railroad has 12 Mallets which are hauling passenger trains on grades 116 ft. per mile and 40 miles long. The Atchison, Topeka and Santa Fe Railway has two Mallet compound engines which were built to haul passenger trains. The service in both these cases is very severe and rather exceptional.

21 The Atlantic and Pacific type engines, under modern operating conditions, are, for high-speed and high-capacity passenger service, the most desirable types. Under certain special circumstances, long continuous opposing grades may justify compounding in connection with these engines. The introduction of the high temperature superheater and the sectional brick arch have helped materially to increase the capacity, fuel economy, and efficiency of passenger engines. The limitations of Atlantic and Pacific type passenger engines are principally controlled by the permissible wheel loads. When 60,000 to 63,000 lb. per pair of drivers is once reached, it is questionable, from many points of view, whether it is wise to go still higher. Hence, when greater tractive efforts are necessary than can be secured from an engine with 180,000 to 190,000 lb. on drivers it becomes a question of either reducing schedules, double heading, or introducing locomotives with an additional pair of drivers. Table 1 summarizes the principal dimensions of typical passenger locomotives.

22 *Freight Locomotives.* Recent developments have made available an exceptional field from which to select locomotives for freight service. It seems limited not so much by the extent to which it is possible to build freight engines as it is by the physical restrictions of the permanent way, the nature of the freight business hauled, length of trains, and topography of the road. These limitations are, of course, mostly very serious, and, as far as track gage is concerned, insurmountable, except perhaps in some special cases.

23 Many Moguls (2-6-0), Ten-Wheel (4-6-0) and Prairie (2-6-2) type locomotives are in freight service today. Their capacities, especially the Mogul and Ten-Wheel types, are hardly adequate for modern service conditions. The Prairie type, due to the possibility of equipping it with a liberal boiler and liberal grate area, has a few advantages over the others.

24 The type of locomotive which has been the standard on many of the American railroads in the past ten years is the Consolidation, or (2-8-0) type. It has been called upon to perform in services ranging from emergency passenger to slow heavy pusher and switching service. Engines of this type are being built for heavy and exacting freight service and their possibilities have not been exhausted. They utilize nearly the

TABLE 1 PRINCIPAL DIMENSIONS OF TYPICAL PASSENGER LOCOMOTIVES

Type	4-6-0	4-6-0	4-4-2	4-4-2	4-4-2	4-6-2	4-6-2	4-6-2	4-6-2	4-6-2	4-8-2	Mallet	Forney	Forney
Cylinders, diameter and stroke, in.	22½x26	22x26	21x26	17½x26	15x25x26	22x28	27x28	25x28	17½x29x28	27x28	29x28	25x38x28	20x24	20x24
Diameters of drivers, in.	69	69	79	73	73	77	79	73	73	80	62	63	61⅝	63
Diameters of boilers, in.	74	72	67⅜	68⅛	72	70	76⅜	77 15/16	70	81¾	83¾	82	66	70
Boiler pressure, lb.	215	200	200	160	220	200	185	200	210	200	180	200	200	200
Firebox, length, in.	138	105	108⅛	102 5/16	109⅝	108	114⅛	126	109⅝	120⅛	114⅛	120⅝	94	94
Firebox, width, in.	108	75	71¼	60⅜	63⅜	66	75¼	108¼	76¼	79¼	84¼	84	105	86
Tubes, number	398	400	347	24, 206	273	24, 173	36, 207	34, 252	26, 199	40, 241	40, 243	495, 424	447	365
Tubes, diameter, in.	2	2	2	5¼, 2	2¼	5⅜, 2	5½, 2¼	5⅜, 2	5½, 2¼	5½, 2¼	5½, 2¼	2, 2¼	1¾	2
Tubes, length, ft. and in.	15-3	14-11	16-10	18-0	14-6	20-0	22-0	20-0	21-0	22-0	19-0	20-6, 6-3	9-0	12-0
Wheel base, driving, ft. and in.	14-4	15-10	7-3	7-0	6-10	13-4	14-0	13-0	13-8	13-10	16-6	32-0	12-6	15-0
Wheel base, engine, ft. and in.	25-6	26-10½	28-2	30-10	32-8	33-4	35-7	34-10	35-1	36-5	37-5	51-4	30-9	23-0
Wheel base, engine and tender, ft. and in.	55-1½	59-3	56-1	62-8	61-1	68-6¼	68-2½	67-4	66-11¾	71-5¾	70-6	85-1	.....	35-10
Weight, on drivers, lb.	171,00	158,000	105,500	116,000	112,125	141,500	172,500	179,500	163,500	197,800	239,000	320,100	120,860	137,500
Weight, of engine, lb.	217,000	209,000	200,000	202,000	231,675	221,100	269,000	284,000	268,800	317,000	330,000	384,800	201,700	229,000
Weight, tender, lb.	135,000	148,000	134,000	149,900	163,325	170,900	161,500	165,700	171,200	175,700	163,400	173,200	.....	...
Fuel	anthracite	soft coal	soft coal	soft coal	oil	oil	soft coal	anthracite	soft coal	soft coal	soft coal	oil	anthracite	peacoal
Heating surface, tubes	3158.5	3104	3041.3	2521	2318	2477	3800	3579	3233	4372	3795	6882†	1825.5	2275.4
Heating surface, superheater	....	...	...	479	....	580	...	821	619	988	845	....	....	...
Heating surface, firebox	228.5	199	185.5	194.5	190	181	220	239	210	253	337	235	156.3	159.3
Heating surface, total	3387	3303	3254.5	2715.5	2508*	2658	4048	3818	3443	4625	4132	7117	1981.8	2434.7
Grate area, sq. ft.	103.8	55	53.5	42.8	48	49.5	59.75	94.8	57.6	66.1	66.7	70	68.5	56
Tractive power, lb.	34,860	31,000	24,700	29,600	23,880	30,000	38,400	40,800	35,000	43,300	58,000	66,800	26,500	25,900

* In addition has 1147 sq. ft. reheating surface.

† Includes 1590 sq. ft. of feedwater heating surface.

total weight of the engine for adhesive purposes. A leading truck of two wheels only is provided permitting of a slightly extended boiler and taking from the drivers only weight enough to secure good guiding qualities. The steaming capacity, firebox size and grate area are necessarily limited, since the entire boiler and firebox must be carried over the drivers. The handicap imposed by the boiler limitations has not, until recently, been very serious.

25 Engines of the Consolidation type, having a maximum tractive power of 60,900 lb. are in service today. The diameter of their drivers is small, 54 in., and their total heating surface compared with the equivalent heating surface of a Mikado engine having the same tractive effort is but 70 per cent. The piston speeds of these large Consolidation engines, compared with the Mikado engine, are considerably higher.

26 The perfection of the high temperature superheater, the brick arch, and the Gaines combustion chamber opens up further opportunities for the Consolidation engine. The application of the superheater results in increased capacity which corresponds, roughly, to a 25 per cent larger boiler capacity than it was possible to provide in connection with saturated steam engines. The brick arches permit increased amounts of heat to be utilized from the fuel burned on restricted grate areas. It should be possible to build Consolidation engines with good steaming capacities and economical fuel requirements that can develop as high as 54,000 lb. maximum tractive effort.

27 An offshoot from the successful Consolidation freight engine is the 12-wheel or (4-8-0) type. This type has not been widely introduced. It has an undesirable ratio between total weight and adhesive weight. The increase in the length of boiler made possible by the four-wheel truck in place of the two-wheel truck of the Consolidation engine nets but little in the direction of increased boiler capacity. The increase in the heating surface of the boiler is at the wrong end. To improve the steaming capacity of the Consolidation engine it is necessary to introduce modifications at the firebox end.

28 The introduction of such modifications has resulted in the Mikado (2-8-2) type engine. By placing a trailing truck underneath the firebox better boiler construction becomes possible; also a decided increase in effective heating surface, a

deeper throat sheet and wider water legs are secured. However, as large a proportion of the total weight of the engine is not utilized for adhesive purposes as with the Consolidation type. By moving the firebox behind the drivers, it also becomes possible to enlarge the boiler diameter, and to increase the relative diameter of drivers, thereby permitting of lower piston speeds. The general construction of the Mikado locomotive is such that it permits of very ample steaming capacity and thus of high sustained tractive efforts. The application of the superheater and brick arch has further increased its capacity in this direction. It is most admirably suited to haul slow maximum tonnage freight trains one day and fast freight trains the next, a condition frequently met in railroad operation.

29 The size of Mikado locomotives for most roads is principally limited by the allowable weights on drivers. It seems to be generally considered that an individual axle load of 60,000 lb. for the better conditions of roadbed, as they are met with today, is very nearly the largest permissible. If so the Mikado engine, as far as size is concerned, has very nearly reached its limit, and the demand for still larger engines will have to be met either by introducing another pair of drivers, making five pairs in all, or by resorting to the Mallet type. With their weight on drivers limited to about 60,000 lb. per pair, it is possible to build Mikados which have a maximum tractive effort of 60,800 lb. with very favorable sustaining qualities at high speeds. The utilization of the superheater and brick arch in connection with the well proportioned boiler and efficiently designed engine make it possible for this size of locomotive to be operated without requiring excessive amounts of fuel so that one fireman can handle all that is needed.

30 To get still larger capacities than are provided by the Consolidation and Mikado types, the Decapod (2-10-0) and the Santa Fé (2-10-2) types are available. The Decapod (2-10-0) type, like the Consolidation and 12-wheel types, has limitations as regards boiler capacity, in consequence of which it is practically adapted to slow service only. Its high proportion of weight on drivers, giving it a high ratio of adhesion is of advantage for this kind of service. The Santa Fé type permits of better boiler proportions than those of the Decapod type, just as the Mikado is better than the Consolidation. The additional pair of drivers

enables a tractive effort about 20 to 25 per cent greater than can be secured from the Mikado engine. Allowing 60,000 lb. per pair, the maximum tractive effort possible should be about 73,000 to 75,000 lb., barring cylinder limitations. Several engines of this type now in service deliver a maximum tractive effort of 71,000 lb. It is reported that they can be handled by one fireman without unduly taxing him.

31 Locomotives with five pairs of coupled wheels have an exceedingly long rigid wheel base. This would introduce many complications should they be placed on territories where track curvature is frequent or severe. Furthermore, the exceptionally heavy pressures on the main pins and the heavy reciprocating parts justify expectation of maintenance difficulties. The long wheel base and the large number of heavy wheel loads in rigid order may be proportionately harder on the track than is the case with large Mikado engines.

32 Another type of engine which deserves consideration for freight service is the Mountain (4-8-2) type, which is similar to the Mikado in all its characteristics. Where fast freight service is abundant and high speed is frequent the additional advantages in guiding qualities secured by the four-wheel leading truck and the slightly increased boiler capacity are important.

33 The Pacific type engine for exclusive fast freight service, where grades are not severe and where this kind of service is heavy, is a very desirable type. A large number of these engines have been built for this service and are giving an excellent account of themselves.

34 The Mallet type offers quite as wide a field to choose from as the Pacific, Consolidation, Mikado, and Santa Fé types combined. Mallet locomotives have been built on both the compound and the simple principle. The wheel arrangement permits of a great number of practical combinations. The application of the superheater and brick arch, feedwater heater and reheater, together with well proportioned boilers and the compound feature has made possible units of large size and of good drawbar pull characteristics at different speeds. At the same time Mallets are economical in fuel consumption. The arrangement of the drivers in two independent sets, and the division of

TABLE 2 DIMENSIONS AND CHARACTERISTICS OF TYPICAL FREIGHT LOCOMOTIVES

Class	4-6-2	2-8-0	2-8-0	4-8-0	2-8-2	2-8-2	2-8-2	2-10-2	2-6-6-2	0-6-6-0	0-6-6-0	0-8-8-0	2-8-8-2	2-8-8-0	0-8-8-0
Cylinders, diameter and stroke, in.	26x26	25x30	24x32	24x30	28x30	28x30	29x28	30x32	22-35x32	22-35x32	24-37x32	26-41x28	27-27x28	28-42x32	26-41x26
Driving wheel, diameter, in.	69	57	54	56	63	63	56	60	56	56	55	51	56	63	56
Boiler, diameter, in.	74½	83¾	84	80	86	86⅛	83¾	88½	83⅞	86	84	90	87⅝	90	89⅞
Boiler, pressure, lb.	180	185	210	200	180	180	170	175	200	225	205	220	160	210	210
Fire box, length, in.	108⅛	126⅛	132	100⅛	108	108	114⅛	132	109	108⅛	117½	126⅛	144⅛	117¼	126⅛
Fire box, width, in.	75¼	114	40	64¼	84	84¼	84¼	96	97	96¼	96	114	96¼	96¼	114
Tubes, number	34, 248	38, 275	406	386	36, 238	43, 304	40, 238	30, 285	36, 243	36, 250	437	42, 270	45, 282	42, 332	38, 277
Tubes, diameter, in.	2, 5⅜	2, 5⅜	2¼	2¼	5½, 2¼	5⅜, 2	5½, 2¼	6, 2¼	5½, 2¼	5½, 2¼	2¼	5½, 2¼	5½, 2¼	5½, 2¼	5½, 2¼
Tubes, length, ft. and in.	20	14-6	15-0	18-10	21-0	21-0	19-0	22-7½	24-0	21-0	21-0	24-0	24-10	24-0	24-0
Wheel base, driving, ft. and in.	12-6	17-0	15-7	16-0	17-0	17-0	16-6	20-9	10-0	10-2	29-8	14-9	15-6	43-3	15-0
Wheel base, engine, ft. and in.	33-7	26-1	24-4	27-1	35-2	35-2	34-10	39-8	48-10	31-2	29-8	40-2	57-5	52-6	40-8
Wheel base, engine and tender, ft. and in.	66-3½	63-1½	57-11¾	62-0	67-2½	67-3½	67-10½	74-4¼	79-3½	70-8¾	62-2¾	75-7¼	88-½	83-1	77-2¾
Weight in working order, total, lb.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Weight in working order, drivers, lb.	172,500	228,500	225,200	213,200	243,200	236,500	242,000	301,800	337,300	352,000	350,100	457,000	435,500	420,000	468.500
Weight in working order, engine, lb.	268,000	254,000	250,300	261,100	318,850	312,000	323,000	378,700	405,000	352,000	350,100	457,000	483,000	450,000	468,500
Weight in working order, tender, lb.	144,400	166,700	142,100	160,900	161,150	159,700	168,000	183,300	158,000	174,000	129,900	168,800	186,400	150,000	184,200
Fuel	soft coal	anthracite	soft coal	soft coal	soft coal	soft coal	soft coal	soft coal	soft coal	oil	soft coal	soft coal	soft coal	soft coal	soft coal
Heating surface, sq. ft. tubes	3538.6	2841.6	3564	3922	4004	4592.8	3740	4841	4659.9	4160	5380	5245	5701	6120	5205.5
Heating surface, superheater	802	622.5	....	....	905	1085	832	970	984.8	858	....	1106	1257	1368	1002
Heating surface, water tubes	28.4	....	....	....	28	27.3	28	....	26.2	....	30	....	40	....	....
Heating surface, firebox	202	256.6	241	182	232	234	283	320	343.2	214	230	352.4	384	326	321.4
Heating surface, total, sq. ft.	3769	3098.2	3805	4041	4264	4854.1	4051	5161	5029.3	4374	5640	5597.4	6125	6446	5526.9
Grate area, sq. ft.	56.5	99.85	36.8	44.7	63	63.1	66.7	88	72.2	72.3	78.3	100	96.5	78.4	99.9
Maximum tractive power, lb.	39,000	51,750	60,928	52,400	57,100	57,100	60,800	71,500	72,800	81,900	76,700	105,500	99,200	100,000	105,000

the total engine weight over these two sets permits readily of meeting track and axle load limitations. Hence these engines offer a large field from which to make selection when the restrictions of the permanent plant are such that they cannot be overcome except by heavy expenditures.

35 Mallet engines can be built to deliver a maximum tractive effort of 140,000 lb. This would mean engines with ten pairs of drivers, each having an average load of about 60,000 lb. As long as 60,000 lb. remains the maximum average practical wheel load, while track curvature remains a consideration, and the gage of the track remains at 4 ft. 8½ in., thereby limiting the height of the center of gravity of engines, it is questionable whether an engine much larger than this can be built. It is not a size which has been reached today, although there are Mallet engines in service which have ten pairs of drivers.

36 A large number of Mallet locomotives are in road and pusher service whose tractive effort working compound range from 73,000 lb. to 105,500 lb. They are meeting with success from the fuel, operating, and maintenance standpoints. The largest number of drivers under the engines referred to is eight pairs, the average weight per pair under the largest one being 58,560 lb. Hence, 105,500 lb. tractive effort is not far from the maximum possible with eight pairs of drivers allowing 60,000 lb. per pair.

37 Table 2 summarizes the principal dimensions and characteristics of typical freight locomotives.

38 *Switch Locomotives.* The types of switching locomotives available range from the six-wheel coupled to the ten-wheel coupled. Recently a Mallet compound engine has been placed in hump yard service by the St. Louis, Iron Mountain and Southern Railroad in order that long trains may be handled without breaking them up. Switching locomotives of five pairs of drivers have a rather long rigid wheel base, perhaps too long for the average yard conditions as they exist on many roads today. Locomotives with four pairs of wheels have a more suitable wheel base, and are capable of delivering comparatively high tractive powers. Locomotives of three pairs of drivers are the most universal in service today. Table 3 summarizes the general dimensions of typical switch engines.

THE PERMANENT PLANT AND ITS RELATION TO MOTIVE POWER SELECTION

39 The permanent plant of a railway as related to the motive power is the track, bridges, passing sidings, terminal yards, engine terminals, including the roundhouses, turntables, coaling stations, watering cranes, ash plant and sanding facilities, and the locomotive repair shops. It has been shown what a wide range of motive power is available from which selections may be made for any class of service. In order that the possibilities of this large field may be fully realized it becomes necessary to study carefully the various changes in the permanent plant to be considered in connection with the introduction of different types and sizes of engines. Such a study will oftentimes show that improvements made to the permanent plant at limited costs will permit of utilizing motive power which will effect a considerable saving in operating expenses, thereby fully justifying the expenditure.

40 *Track.* The improvement of the track with a view of making possible higher train speeds and heavier axle loads is a complicated problem. Track improvements such as laying heavier rails, respacing of ties, increasing the carrying power of the sub-grade by drainage, deepening and improving the nature of the ballast are continually under way. The tendency is to strengthen and improve track as rapidly as earnings will permit, so that full advantage may be taken of all that is offered in the way of possibilities to increase engine capacities and train tonnage. The state of good track today, laid with 90 and 100 pound rail, is such that it readily allows 60,000 lb. axle loads, which is about as high on the average as it is advisable to go. While the track may be such that, should heavy wheel loads be imposed, it would result in increasing the maintenance costs, the tendency may nevertheless be to improve this lighter track in the near future by introducing ballast and relaying the lighter rail with heavier. In such cases, and they are very prevalent, the present track conditions should not be permitted to limit the motive power sizes too greatly because of the economical advantages of increased train loads.

41 Bridges not only restrict the individual axle load, but also the total weight. Moderate expenditures in the direction of bridge improvement, plus the regular program of bridge

TABLE 3 GENERAL DIMENSIONS OF TYPICAL SWITCHING LOCOMOTIVES

Class	0–6–0	0–6–0	0–8–0	0–8–0	0–8–0	0–10–0	Mallet
Service	ordinary	ordinary	ordinary	ordinary	ordinary	hump	hump
Cylinders, in.	21 x 28	21 x 26	21 x 28	27 x 30	23½ x 32	24 x 28	26 – 40 x 32
Driving wheel diameter, in.	57	52	51	57	57	52	55
Boiler, diameter, in.	67⅜	80	68	83½	80	80	84
Boiler, pressure, lb.	180	200	180	165	200	210	200
Firebox, length, in.	72⅛	83 15/16	114	111⅛	120	108	126
Firebox, width, in.	65¼	66	42¼	75¼	75¼	73	96
Tubes, number	304	400	260	450	511	447	401
Tubes, diameter, in.	2	2	2¼	2	2	2	2¼
Tubes, length, ft. and in.	16–0	11–0	14–2	15–0	14–9	19–0	21–0
Wheel base, driving, ft. and in.	11–6	11–0	15–0	16–0	16–0	19–0	39–4
Wheel base, engine, ft. and in.	11–6	11–0	15–0	16–0	16–0	19–0	56–7
Wheel base, engine and tender, ft. and in.	42–6	34–9¼	47–0	49–2¾	48–9½	54–5½	85–2¼
Weight in working order, lb.	......	......	......	......	......	......	......
Weight in working order, on drivers, lb.	166,400	165,000	164,000	229,000	223,950	270,000	395,000
Weight in working order, of engine, lb.	166,400	165,000	164,000	229,000	223,950	270,000	435,000
Weight, in working order, of tender, lb.	104,300	135,000	91,000	134,000	140,050	149,600	155,000
Fuel, kind	soft coal	soft coal	soft coal	soft coal	soft coal	soft coal	soft coal
Heating surface, tubes, sq. ft.	2535	2286	2157	3514.7	3924	4422.4	4281
Heating surface, feedwater heater tubes, sq. ft.	......	......	......	......	......	......	1230
Heating surface, firebox, sq. ft.	144	169	163	194.6	179	203	252
Heating surface, total, sq. ft.	2679	2455	2320	3709.3	4103	4625.4	5763*
Grate area, sq. ft.	32.6	38.5	33.6	58.1	62.7	55	84
Maximum tractive power, lb.	33,140	37,500	37,040	53,800	52,700	55,362	94,575

* In addition has 890 sq. ft. of superheater heating surface.

renewals and improvements may permit of taking advantage of a type of locomotive which would effect economies in operating expenses that would more than pay for the unusual improvement expenses incurred.

42 *Yards and Passing Sidings.* Unless the yards and passing sidings are adequate to take care of longer trains the improvements expected by the introduction of larger locomotives will not materialize and the operating expenses will show but little decrease. The long trains are apt to be tied up and blockades will occur which are expensive as well as demoralizing.

43 *Locomotive Terminals.* Except for side and overhead clearances, the coal chutes, watering cranes, sanding and ash handling facilities, will have but little effect on the choice of new locomotives. Ash pit construction may need a little modification to permit of heavier wheel loads. The roundhouse may be inadequate to permit of housing the larger engines suitably. The turntable may be too short or too light to turn the heavier engines. Limited or inadequate locomotive terminals, in part or in whole, should not be permitted to stand in the way of introducing the most economical locomotive available. It is becoming more generally recognized that as motive power increases in size it becomes relatively more important and economical to provide means at locomotive terminals whereby the turning of power is expedited.

44 *Shop Facilities.* It would be manifestly impractical for a railway to undertake to rebuild its entire shops for the sake of handling a very large engine of the Mallet type. As a rule, however, especially on the larger roads, the present shopping facilities are such that a railway, from this point of view, should find but few limitations to the size of locomotives it may find desirable to operate. Then again the adopted program of shop facility renewals and modifications, continually necessary as business keeps growing and old parts of the shops depreciate, tends to take away from the seriousness of this consideration.

45 *Clearances.* Clearances through cuts, of water cranes, buildings, and other fixed structures along the right of way have some effect in determining the size of the engine to be selected, as well as the amount of the expenditures to be made for improvement.

THE RELATION OF OPERATING EXPENSES TO THE SELECTION OF MOTIVE POWER

46 The effect of the selection of locomotives for passenger and switching service on operating expenses does not play as important a role as it does in the selection of engines for freight service. The choice of passenger and switch engines is determined very largely by imposed conditions resulting from circumstances peculiar to the nature of these two kinds of service. Larger and heavier switch engines are usually made necessary by heavier trains handled in the yards. The demand for larger and improved passenger engines results from the necessity of maintaining high speeds with trains which are growing in weight due to the introduction of steel equipment and more cars. It should be observed, however, that the economy of the various types of engines available, from the fuel, lubricating, and maintenance points of view has an important bearing on the ultimate selection. That type and size of engine should be chosen which will operate with the least expense for fuel, water, and repairs, and which will keep as low as possible, consistent with the size of the engine in regard to the service requirements for the present and the future, the expeditures for improvement to the permanent plant.

47 In the selection of power for freight service the effect of the various types and sizes on the operating costs should go a long way towards determining the most economical engine to choose. The largest part of the gross revenue of railways results from freight transportation, and the greatest proportion of their operating expenses are consumed in conducting this transportation. The nature of freight service permits a much greater flexibility as far as choice of the motive power is concerned. A study should be made to determine which type and size will effect the greatest net saving in operating expenses after deducting all overhead and additional maintenance charges resulting from the improvements necessitated by the introduction of the engine. Only by such a study as this in conjunction with considering the service conditions and the tendency of future development can the ultimate selection be made with any degree of correctness.

48 The items of operating costs and overhead charges which should be considered in such a study are the following:

a Transportation expenses
- Fuel
- Water
- Lubricants for locomotives
- Other supplies for locomotives
- Enginehouse expenses
- Train supplies and expenses
- Enginemen's wages
- Trainmen's wages

b Maintenance of equipment
- Locomotive repairs
- Freight train car repairs

c Maintenance of way and structures
- Ballast
- Ties
- Rail
- Other track material
- Labor, roadway and track
- Bridges, trestles and culverts
- Buildings, fixtures and grounds

d Overhead charges
- Interest on locomotives and improvements to permanent plant
- Depreciation of locomotives and improvements to permanent plant
- Taxes and insurance on locomotives and improvements to permanent plant.

49 To attempt to discuss within the limits of this paper the effect of locomotive types and sizes on each one of the items of railway expenses concerned would be impossible. Wellington, Webb, and Henderson have formulated many of the principles involved and reference to the works of these men will reveal considerable valuable data and information on this subject. The statistics kept by the individual railways will furnish additional information necessary for the analysis. The application of logical reasoning and the use of recent data established by both laboratory and service tests will further aid in making correct comparisons. The suggestions regarding the various items of

expenses and their relation to motive power selection will therefore be general and seek rather to point out the inherent tendencies of these expenses and their importance.

50 *Fuel.* Fuel is the largest single item of locomotive operating expenses and therefore the most important. The fuel consumption may be divided into the following classes: (*a*) fuel used while actually working on the road; (*b*) fuel used while drifting and waiting; (*c*) fuel used at terminals for firing up. As locomotives grow larger their fuel consumption per unit increases, but not nearly in proportion to the increase in their size. It does not take very much more coal to fire a large locomotive than a small one. The fuel losses of a large locomotive due to radiation while waiting or drifting are but slightly larger than those of a smaller locomotive. The increase of fuel consumption of large saturated simple steam engines when working at their full capacity is more nearly in proportion to the increase in their size. The introduction of the superheater, feedwater heater and reheater, the increase in heating surface of the boiler, the brick arch, the utilization of compounding in large engines of the Mallet type, application of improved valve gear and compound air pumps, and more careful attention to the design of steam passages and steam engine efficiency have accomplished remarkable results in keeping the fuel consumption of large locomotives down so that their consumption per train-mile is increased but slightly over that of the recent types of smaller saturated steam locomotives.

51 Numerous tests and service records have revealed that large superheater Mikado locomotives which have been placed in service recently haul trains of 45 and 50 per cent greater tonnage with the same amount of coal that was formerly consumed by the Consolidation locomotives they replaced. Even the coal consumption of Mallet engines with grate areas up to 100 sq. ft. has not grown in any way proportionate to the increase in their hauling capacity. Modern engines when running at shortened cut-offs over those portions of the road other than the ruling grades exhibited a still greater economy than when working on the heaviest grades. Some service tests of recently built Mikado engines on the Delaware, Lackawanna and Western Railroad clearly demonstrated these facts. Their economy in fuel consumption as compared with that of the old Consolida-

tion type, both operating over heavy grades at full load, was 20 per cent. The economy effected over easy grades while running at shortened cut-offs was 39.3 per cent, almost twice as much. The average was 29.1 per cent.

52 The conclusions to be reached in regard to the fuel consumption of larger locomotives equipped with those fuel saving devices which have proved their merit is that it increases but slightly as their hauling capacities increase. It depends of course largely upon the size of locomotives in service as to what the actual increase will be on the train-mile basis over the consumption of the old engines, and this must be taken into consideration.

53 *Water.* The same things that are true of fuel consumption, are true of water consumption, only perhaps more so, especially with superheater engines. Water economy increases but slightly with the increase in locomotive sizes.

54 *Lubrication of Locomotives.* It is safe to conclude that the cost of locomotive lubrication increases more or less directly in proportion to the increase in the size of the locomotive as reflected by the wheel and cylinder arrangements.

55 *Other Supplies for Locomotives.* This item is affected slightly, if any, by an increase in locomotive capacities.

56 *Engine House Expenses.* As the size of engines increases the cost of enginehouse expenses per engine handled increases. However, as the size of engines increases the number handled at the terminals decreases. This decrease should approximately counterbalance the increase in cost per engine handled.

57 *Train Supplies and Expenses.* The item of train supplies and expenses per train-mile is affected but slightly by a decrease in train mileage.

58 *Wages of Enginemen.* History clearly shows that the wages of engineers and firemen per trip increase as the engines grow larger. Prompter movements made possible by more powerful locomotives reduce the cost of overtime.

59 *Wages of Trainmen.* The wages of trainmen do not increase per train-mile. If the business is handled a little more promptly through the decrease in the number of trains handled there will be a corresponding decrease in the wages paid for overtime of trainmen.

60 *Locomotive Repairs.* The cost of locomotive repairs does

not increase in direct proportion to the increase in hauling capacity. Under modern conditions it will perhaps be safe to assume that about 60 per cent of the total cost of locomotive repairs varies directly as the weights of locomotives increase.

61 *Freight Train Car Repairs.* The item of freight train car repairs per train-mile increases slightly more than in direct proportion to the increase in the number of cars hauled in the longer trains by the larger locomotives. Improvements in car construction, however, are rapidly counteracting this tendency.

62 *Maintenance of Track, Bridges and Buildings.* General observations seem to indicate that about 40 to 50 per cent of the cost of maintaining track per train-mile varies directly with the average increase of weight on drivers. The many improvements in track construction continually under way, the introduction of treated ties, heavier rails of improved steel and better drainage facilities all help to reduce to a minimum the effect of heavier power on the roadbed. The improvements to bridges, buildings and structures, such as roundhouses, turntables and shops, the lengthening of passing sidings and the extension of yard facilities have a further effect on the cost of maintenance of way and structures as related to the increase of motive power sizes.

63 *Overhead Charges.* The overhead charges include interest, depreciation, taxes, and insurance and should be carefully estimated.

FINAL DETERMINATION OF MOST ECONOMICAL LOCOMOTIVE TO ADOPT

64 Taking each one of the items into consideration, estimating the reduction in train mileage effected by each type, the gross savings in operating expenses effected based on the amounts of business on hand or in sight, and deducting therefrom all overhead charges arising from the additional improvements necessary to make the operation of the different types of locomotive under comparison practical, will reveal which particular locomotive is the most economical in size and type.

65 As far as a standard engine of any kind for an entire road is concerned the general conditions obtaining will have some bearing. A road may for instance be composed partly of divisions whose grades are moderate and partly of divisions whose grades are severe. If the variations are not great a compromise standard might be adopted. If on the other hand there

is a large difference, it may be wiser to seek to establish two or three standards and confine them to their particular territory with a view to getting the maximum efficiency from every portion of the property. Then again there are many shorter territories such as pusher grades and divisions through mountainous country, the motive power selection for which is a distinctly local problem. In every case, whether it is the broad problem of establishing standards for the entire system, or selecting an engine for a local territory, the problem might well be reduced to an economic study, comparing several available types and sizes, the extent of the improvements necessary to make their operation practical, and the net savings which it is estimated will be effected by their introduction.

SUMMARY

66 In designing new locomotives all of the conditions must first be analyzed and then the design made to suit them. The actual design of the engine finally chosen may be approached with confidence because of accumulated knowledge and experience. Due to the great possibilities of favorably effecting operating results by building locomotives which are exactly suited to their work, a study of the conditions becomes vitally important. To show what these conditions are has been the object of this paper. The fact that the most powerful locomotives of most approved design are also the most economical should be more generally appreciated. It is to be hoped that the future will see more advantage taken of the modern locomotive in accordance with its possibilities in relation to grade revision and its ability to reduce operating expenses to a minimum. The ultimate benefits which will result will certainly be justified to the fullest extent.

THE PROPERTIES OF SATURATED AND SUPERHEATED AMMONIA

By William E. Mosher

ABSTRACT OF PAPER

In this paper the various scattered experimental data on the properties of ammonia are collected and correlated. An attempt is made to reconcile these data by means of well-known thermodynamic laws and principles so that the results may be consistent with each other.

The paper treats of both the saturated and the superheated vapor; also of liquid ammonia. Formulae to express the various properties are proposed, some being of rational form with empirical constants, others being wholly empirical. The constants in the various formulae are determined by aid of the experimental data. The values resulting from the use of these formulae are compared with the experimental values and substantial agreement is shown. Discussions of the validity of the different formulae are given.

The paper contains no working tables of the properties of ammonia, but such tables have been prepared for both the saturated and the superheated vapor, and they will appear, together with a Mollier diagram for ammonia, in due time as a bulletin of the Engineering Experiment Station of the University of Illinois.

THE PROPERTIES OF SATURATED AND SUPERHEATED AMMONIA

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The vapor of anhydrous ammonia first became of interest in the field of mechanical engineering with the advent of Carré's absorption and Linde's compression refrigerating machines. With the development of the refrigeration industry this vapor has become more and more important and an accurate knowledge of its properties is highly desirable.

2 As in the case of steam and many other vapors, the first reliable experimental knowledge of the properties of ammonia was derived from the work of Regnault. He determined experimentally the relation between the pressure and the temperature of the saturated vapor and expressed it by means of empirical formulae. He also determined the relative volumes of the superheated vapor at different pressures along an isothermal for the temperature 8.1 deg. cent., the specific heat, the theoretical density and the experimental density of the gas. The determinations made by Regnault of the specific heat of the liquid and the latent heat of vaporization were lost in the reign of the Commune in 1871; twelve of the determinations of the latter magnitude, however, have been found.

3 The tables now used most extensively in refrigeration work and included in most handbooks on refrigeration are those of Wood, based upon Regnault's experiments. Peabody's tables, which appeared at about the same time, were based upon the work of Ledoux and upon the same form of equation of state, namely that derived by Zeuner and applied to ammonia by Ledoux. Since these tables were published the properties of ammonia have been made the subject of considerable experi-

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. **All papers are subject to revision.**

mental work and various tables have been issued, although comparatively little is known of the subject even now when its importance in technical work is considered. Probably the most accurate table for the range covered is one recently calculated by Goodenough, although this was designed for class room purposes and is not based upon refined analysis.

4 The present investigation was undertaken with the object of collecting and correlating the various scattered experimental data on the subject of the properties of ammonia. An attempt has been made to reconcile these data by means of well-known thermodynamic laws and principles so that the results may be consistent with each other; and to express the various properties by means of formulae from which tables and charts in English units may be prepared. It is realized, however, that the experimental evidence is not as complete as could be desired and that more accurate experimental work may render necessary slight revision of the values of the constants in the equations here presented.

5 *Notation.* Throughout the investigation the absolute temperature of melting ice on the Fahrenheit scale has been taken as 491.64 deg., so that absolute zero is at 459.64 deg. fahr. The value of 777.64 ft. lb. has been used for the mechanical equivalent of heat. The notation used is as follows:

J = Joule's equivalent.
A = Reciprocal of same.
t = Temperature on the F. or the C. scale.
T = Absolute temperature.
p = Pressure.
v = Specific volume.
γ = Specific weight.
u = Intrinsic energy.
i = Heat content at constant pressure.
s = Entropy.
r = Latent heat of vaporization.
ρ = Internal latent heat.
ψ = External latent heat $= Ap(v'' - v')$.
c = Specific heat.
c_p = Specific heat at constant pressure.
x = Quality of vapor mixture.

Subscript $_k$ indicates critical data.
$'$ indicates properties of liquid.
$''$ indicates properties of saturated vapor.

6 *Relation between Pressure and Temperature of Saturated Vapor.* To express the relation between the pressure and temperature of saturated vapors scores of formulae have been proposed, some being of more or less rational form involving empirical constants, but the greater number being purely empirical.

a Biot's equation as used by Regnault has the form

$$\log p = a - b\,\alpha^n + c\,\beta^n$$

where $n = t - k$

The same formula was used in the computation of Peabody's tables.

b Wood used Rankine's formula in the form

$$\log p = a - \frac{b}{T}$$

with $a = 6.2495$ and $b = 2196$; limits, — 20 deg. fahr. to 100 deg. fahr.

c Goodenough used the Bertrand formula in the form

$$\log p = \log k - n \log \frac{T}{T - b}$$

with $\log k = 5.87395, n = 50, b = 84.3$.

7 It does not seem to be possible to find constants which will make equations of the above forms apply over more than a limited range of temperature, either with steam or with other vapors. An equation for steam has, however, recently been proposed by Marks[1], which is remarkable in that it gives pressures agreeing closely with experimental values throughout the range from 32 to 706.1 deg. fahr., the latter point being the critical temperature. This equation is based on the one used by van der Waals

$$\log \frac{p_k}{p} = a\left(\frac{T_k}{T} - 1\right) \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where p_k and T_k denote respectively the critical pressure and critical temperature. Instead of being a constant as used by van der Waals, *a* varies for different substances and for different temperatures with the same substance. Professor Marks found values of *a* at different temperatures for steam and then found an expression for its value in terms of the temperature and the critical temperature. By substituting this expression for a and the proper values for p_k and T_k in equation [1], he arrived at the following relation between the pressure and temperature of saturated steam

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[1] Trans. Am.Soc.M.E., vol. 33, 1911, p. 361.

$$\log p = a - \frac{b}{T} - cT + eT^2 \ldots\ldots\ldots\ldots [2]$$

where

$a = 10.515354$
$b = 4873.71$
$c = 0.00405096$
$e = 0.000001392964$

8 In the present investigation an attempt was made to use the above method to determine the pressure-temperature relation of ammonia. Several factors rendered the use of this method undesirable, among them being the sensitiveness of the method to changes in the critical data and the uncertainty of these data for ammonia, the lack of experimental data at temperatures near the critical point, and the large discrepancies existing in the data throughout the entire range. As will be seen later, however, this equation plays an important part in the present investigation.

9 Physicists have repeatedly attempted to find a relation between the pressures of different vapors at the same temperature such that a determination of the function $p = f(t)$ for one vapor would serve to determine this function for all other vapors. Ramsey and Young proposed the law

$$R = R' + k\ (T - T')$$

where R and R' are the ratios of the temperatures of two saturated vapors at two different pressures, and T and T' are the temperatures of one of the vapors corresponding to these pressures. They show that the law holds very closely for some 22 different substances arranged in 23 different pairs. In their paper they use the T and T' in the term $k\ (T - T')$ as being indiscriminately the numerators or the denominators of the ratios R and R'; i. e. they use the two equations

$$\frac{T_b}{T_a} = \frac{T'_b}{T'_a} + k'\ (T_a - T'_a) \ldots\ldots\ldots\ldots [3]$$

$$\frac{T_a}{T_b} = \frac{T'_a}{T'_b} + k\ \ (T_a - T'_a) \ldots\ldots\ldots\ldots [4]$$

without making any mention of the change from one form to the other and without recognizing that the two forms lead to different results.

10 This law has been corroborated by the work of Richardson and by the work of Ramsey and Travers on crypton, argon and xenon.

11 Ayrton and Perry, and Everett have each remarked upon the lack of symmetry of equation [3] and have shown that equation [4] is symmetrical. This is most clearly demonstrated by Moss, who shows that [3] may be thrown into the form

$$\frac{T_b}{T_a}=\left[\frac{T_b'}{T_a'}-k'T_a'\right]+k'T_a$$

and [4] may be thrown into the form

$$\frac{T_a}{T_b}=\left[\frac{T_a'}{T_b'}-kT_a'\right]+kT_a$$

since T_a' and T_b' are the temperatures corresponding to some particular vapor pressure, these equations may be written respectively

$$\frac{T_b}{T_a}=k'T_a+c' \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

and

$$\frac{T_a}{T_b}=kT_a+c \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

12 Equation [6] may be written in the simple form

$$\frac{1}{T_b}=c\,\frac{1}{T_a}+k \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

$\frac{1}{T_b}$ and $\frac{1}{T_a}$ thus being linear functions of each other.

13 Since equation [7] may be written

$$A-\frac{B}{T_b}=A'-\frac{B'}{T_a}$$

it follows that any equation to be applicable to all vapors in the same form with only its constants changed, and at the same time to be consistent with the temperature ratio law as stated above, must satisfy the condition that

$$p=f\left(A-\frac{B}{T}\right)$$

all other constants remaining the same for all vapors. Now, it happens that the equations which may be thrown into this form.

such as the Rankine short form, the Roche equation, etc., do not satisfy the experimental data for steam throughout its range with the necessary degree of accuracy. On the other hand, the Marks equation, which does satisfy these data with remarkable accuracy throughout the complete range, cannot be thrown into the required form. In view of the various considerations mentioned it has been decided in the present investigation to accept the temperature ratio law as expressed in equation [7], to use water as the standard substance, to use the Marks equation, equation [2], as representing the pressure-temperature relation for water, and to make a step-by-step solution of the pressure-temperature relation for ammonia by means of these equations.

14 The method used in applying the temperature ratio law and in determining the value of the constants c and k in equation [7], is that used by Moss, who has applied it to 17 different vapors. A description of this method and of the construction of Fig. 1 is given in Appendix No. 1.

15 After plotting the points representing the experimental data the straight line shown in Fig. 1 was drawn in a manner such as to represent all the points in the best possible manner.

16 The effectiveness of any method that enables one to throw any given data into a form such that it may be represented by a straight line lies in the fact that it discloses immediately and strikingly any departure from the general trend and reveals unerringly points that depart from this trend. It enables one to give various observations their proper weight and it affords a much safer basis of extrapolation than can be obtained from curves. The case in hand illustrates this principle. If the points are plotted on the regular pt plane it is easily seen that no smooth curve such as represents a law of nature, could, if passed through Regnault's lower temperature points and Brill's lower points, at the same time pass through Brill's points in the region -80 to -30 deg. fahr. Further than this the chart discloses nothing, as an infinite number of curves could be drawn, giving different weights to the different points, or all points could be given equal weight and the equation could then be determined by least squares. An inspection of Fig. 1 shows, however, that the straight line which best represents the whole range represents very accurately Regnault's lower points, Brill's highest point and all of his points from -80 to -110 deg. fahr. In the range -80 to -30 deg. fahr. all of Brill's points lie above the line, as does Davies' -41.8 deg.

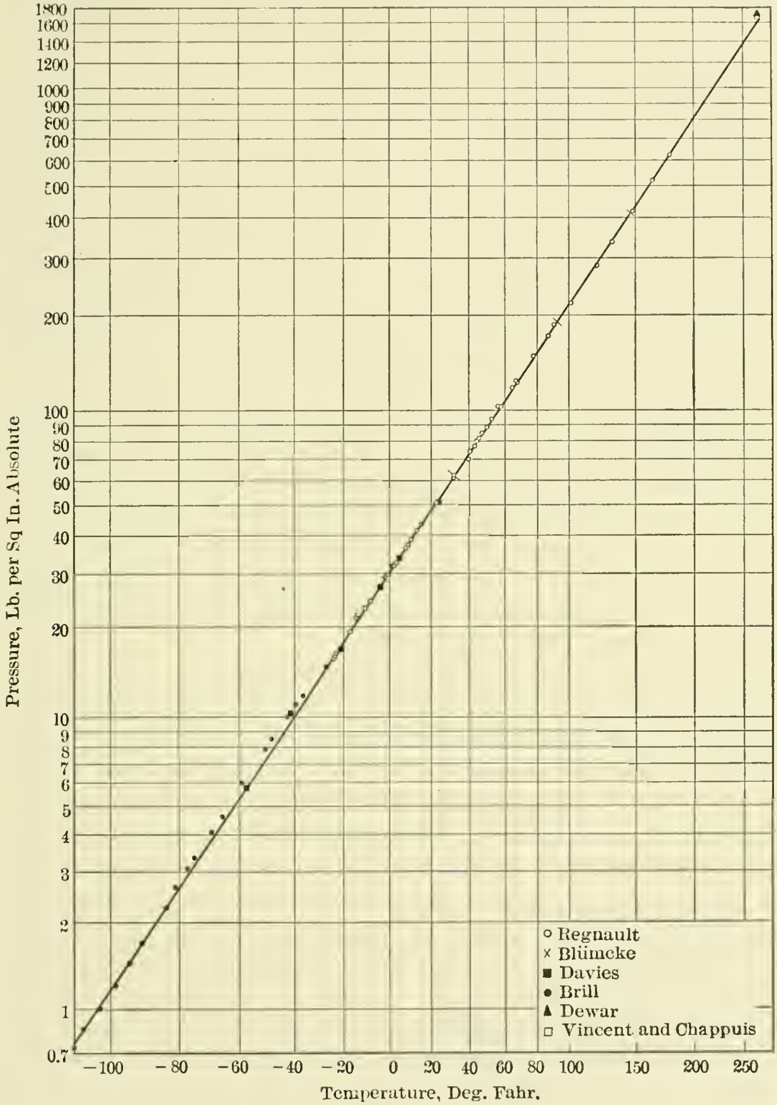

FIG. 1 CURVE SHOWING AGREEMENT OF PRESSURES FOUND BY TEMPERATURE RATIO LAW WITH THOSE FOUND BY EXPERIMENT

fahr. point. It is significant, however, that Davies' -57.64 deg. fahr. point lies exactly on the line at precisely the point where Brill's points lie farthest from it.

17 Through the range -30 to $+100$ deg. fahr. the line represents the experimental points very accurately; above 100 deg. fahr. Regnault's points lie slightly below the line. Now all of Regnault's points above 100 deg. fahr. belong to his third series of experiments. In all of the higher pressure points of this series Regnault used a closed manometer and extensive corrections had to be applied to the height of mercury observed, and a comparison of the experiments in the range 40 to 90 deg. fahr. where the second and third series overlap shows that invariably the points determined in the third series by the use of the closed manometer lie below those determined in the second series by the use of the open manometer. The conclusion is evident that there was probably an error in the correction applied by Regnault to his readings with the closed manometer; the fact that these points lie below the line should therefore not be taken as conclusive evidence of the incorrectness of the line.

18 As to the critical data, it is seen that the points of both Dewar, and Vincent and Chappuis lie above the line. If the line be taken as correct this indicates either higher temperature, lower pressure, or both, at the critical point.

19 The same is the case with the determination of the critical data for water; as methods have been improved and greater precautions taken in the experimental work, the value found for the critical temperature has steadily risen until the latest determination, that of Holborn and Bauman, is 30 deg. higher than that found by Nadejdine 25 years earlier. It is reasonable to assume that the same errors may have been made in the ammonia determinations and that the true critical temperature of ammonia is higher than that found by either Dewar or Vincent and Chappuis. In the present investigation the critical data of ammonia are not of prime importance and the purely arbitrary assumption has been made, on the basis of the above reasoning and for want of better data, that the higher of the critical pressure determinations, that of Dewar, is correct. The corresponding temperature as determined by the temperature ratio law has been taken as the critical temperature. The resulting values are

$$p_k = 1690 \text{ lb. per sq. in.}$$

$$t_k = 273.2 \text{ deg. fahr.}$$

20 Since the above conclusions were drawn the articles giving the determinations of Jaquerod and Scheffer have been found. If plotted in Fig. 1 the point representing Jaquerod's determination falls below the straight line and that representing Scheffer's value falls almost exactly upon it. If Scheffer's value for the critical temperature is substituted in the temperature ratio law the resulting pressure is 1638.6 lb. per sq. in. while his experimental value is 1635.7 lb. per sq. in., the difference being about 1/6 of one per cent. These results offer corroboration of the correctness of the location of the straight line in Fig. 1, although the arbitrary values chosen for the critical temperature and pressure may be too high.

21 The equation of the straight line in Fig. 1 is

$$\frac{1}{T_a}=1.70356\,\frac{1}{T_w}-0.0002242\ldots\ldots\ldots\ldots\ldots\quad[8]$$

In constructing tables with pressure as the argument the temperature of saturated steam at any pressure is found from steam tables. The corresponding saturation temperature of ammonia is then found by using equation [8] in the form

$$T_a=\frac{1}{\dfrac{1.70356}{T_w}-0.0002242}$$

22 If temperature is taken as the argument the temperature at which steam will be saturated under the same pressure may be found by using equation [8] in the form

$$T_w=\frac{1}{\dfrac{0.587006}{T_a}+0.0001316}$$

and the corresponding pressure is found from steam tables.

23 *Specific Volume of the Liquid.* There are available three sets of experimental data from which the specific volume of the liquid may be determined. Lange determined the density of liquid ammonia over the temperature range of −56 to +208 deg. fahr.; Dieterici, working by Young's method, obtained simultaneously the specific volumes of the liquid and of the saturated vapor over a temperature range of 32 to 222 deg. fahr. In addition to these there are the specific gravity determinations of d'Andréeff, from which the specific volume may be calculated; these experiments cover the range of 14 to 68 deg. fahr.

24 In Fig. 2 the experimental values are plotted with specific volumes as ordinates, and temperatures as abscissae. The form of equation used to express the volume of the liquid in terms of the temperature is that used by Avenarius, or

$$v' = a - b \log (t_k - t) \ldots\ldots\ldots\ldots\ldots\ldots [9]$$

The curve shown in Fig. 2 up to 160 deg. fahr. represents this equation with the constants as follows:

$a = 0.06335$

$b = 0.016$

$t_k = 273.2$

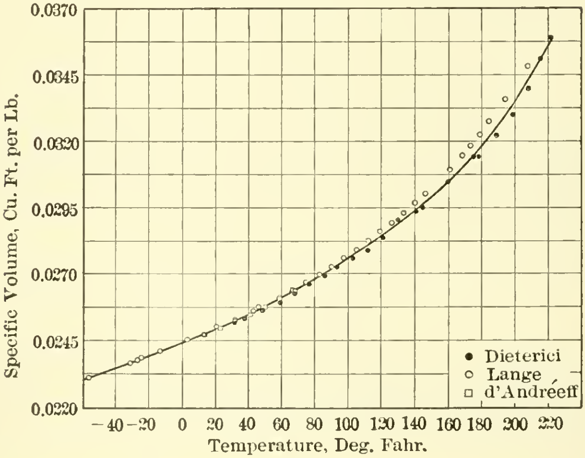

Fig. 2 Curve showing Agreement of Volumes of Liquid as calculated with Those found by Experiment

25 In determining these constants the work of Dieterici was given the most weight, both because the methods he employed are superior to the others, and because the volumes of the vapor to be used with these values are those determined by Dieterici by the same method in the same series of experiments.

26 The part of the curve above 160 deg. fahr. represents the values found by the method discussed in Paragraphs 45 to 50.

27 *Latent Heat of Vaporization.* Since the experimental information regarding the latent heat of vaporization of ammonia is too meager to be used as a basis for the determination of the relation existing between it and the temperature of vaporization, this

relationship will be determined from other considerations and the available data used as a check on the method.

28 Let [7] be differentiated with respect to the pressure. Then

$$\frac{-\dfrac{dT_a}{dp}}{T_a^2}=\frac{-c\dfrac{dT_w}{dp}}{T_w^2}$$

which may be written

$$\frac{T_a\dfrac{dp}{dT_a}}{T_w\dfrac{dp}{dT_w}}=\frac{1}{c}\cdot\frac{T_w}{T_a}$$

or since

$$\frac{T_w}{T_a}=c+k\,T_w$$

there results

$$\frac{T_a\dfrac{dp}{dT_a}}{T_w\dfrac{dp}{dT_w}}=1+\left(\frac{k}{c}\right)T_w\ldots\ldots\ldots\ldots\ldots\ldots[10]$$

Now by the Clapeyron relation connecting the latent heat and the absolute temperature of vaporization with the change of volume during vaporization

$$\left(\frac{v''-v'}{r}\right)=\frac{1}{144AT\left(\dfrac{dp}{dT}\right)_{sat}}$$

Substituting in equation [10]

$$\frac{\dfrac{(v''-v')_w}{r_w}}{\dfrac{(v''-v')_a}{r_a}}=1+\frac{k}{c}T_w\ldots\ldots\ldots\ldots\ldots\ldots[11]$$

or with the proper values of the constants introduced

$$\frac{\dfrac{(v''-v')_{\mathrm{w}}}{r_{\mathrm{w}}}}{\dfrac{(v''-v')_{\mathrm{a}}}{r_{\mathrm{a}}}}=1-0.0001316T_{\mathrm{w}}\ldots\ldots\ldots\ldots\ldots[12]$$

29 The quantity $\dfrac{(v''-v')_{\mathrm{w}}}{r_{\mathrm{w}}}$ may be found from steam tables or as follows: From the Clapeyron relation

$$\frac{(v''-v')_{\mathrm{w}}}{r_{\mathrm{w}}}=\frac{1}{144\ AT\left[\dfrac{dp}{dT_{\mathrm{w}}}\right]_{\mathrm{sat}}}$$

By differentiating [2]

$$\left[\frac{dp}{dT_{\mathrm{w}}}\right]_{\mathrm{sat}}=p\left[\frac{11222.13}{T_{\mathrm{w}}^{2}}+0.00000641484\ T_{\mathrm{w}}-0.00932768\ T_{\mathrm{w}}^{2}\right]$$

Substituting this value in the Clapeyron relation

$$\frac{(v''-v')_{\mathrm{w}}}{r_{\mathrm{w}}}=\frac{1}{p\left[\dfrac{2078.07}{T_{\mathrm{w}}}-0.00172726\ T_{\mathrm{w}}+0.00000118787\ T_{\mathrm{w}}^{2}\right]}\quad[13]$$

30 By the use of equations [12] and [13] $\dfrac{(v''-v')a}{r_{\mathrm{a}}}$ may be calculated and if either numerator or denominator is known the other may be found. Fortunately there are available the experimental determinations of Dieterici of the specific volumes of the liquid and saturated vapor; the former were given in Pars. 23–26 and the latter will be discussed in Pars. 41–44. From these determinations various values of $(v''-v')$ were found and values of r calculated as described above.

31 According to the generally accepted ideas concerning the critical point, at that point $r=0$ and $\dfrac{dr}{dt}=-\infty$. These facts led Thiesen to suggest as an empirical formula

$$r=c\ (t_{\mathrm{k}}-t)^{\mathrm{n}}$$

This form of equation has been used for water by Thiesen, Henning, and Marks and Davis, and for ammonia by Dieterici. When plotted on logarithmic cross-section paper it is represented by a straight line, the slope being equal to n.

32 The values of r found by the above method were plotted to the corresponding values of $(t_k - t)$ on logarithmic cross-section paper and were found to lie almost exactly on a straight line, indicating that the Thiesen formula might be used to express the desired relation. The formula may be written in the form

$$\log r = \log C + n \log (t_k - t)$$

and it was found that the values of the constants giving the best agreement with the plotted points are

$$\log C = 1.856064$$

and

$$n = 0.37$$

Therefore the final equation is

$$\log r = 1.856064 + 0.37 \log (273.2 - t) \ldots\ldots\ldots\ldots [14]$$

33 The available data concerning the latent heat of vaporization are given in Table 1 and the various points are plotted in Fig. 3, the full line in this figure representing equation [14]. Of the determination of r made by Regnault, the greater number were lost, but 12 were saved and later published. The results of these experiments do not give r directly and have been variously interpreted by different writers. The table contains the interpretation of Jacobus and the three values of r as quoted from Regnault by Dieterici. Two values for r are given by von Strombeck, one being an average of 12 experiments, the other of eight. The value given by Franklin and Kraus is an average of three determinations at the normal boiling point, and the value obtained is exactly the value deduced by the same writers from the absolute boiling point and the molecular elevation. A different value was found at the normal boiling point by Estreicher and Schnerr. The values given by Denton and Jacobus, represented in Fig. 3 by crosses, were calculated from readings taken during a test of an ammonia compressor, and hence cannot be considered of much weight; because of the scarcity of scientific data, however, these points are included in the table and chart.

34 In Fig. 3 are also plotted the curves that represent various equations used in calculating the latent heat of vaporization, as given in the various existing tables. These are plotted exactly as given and it should be remembered that there is some variation in the value of the heat unit used by different writers; consequently the

various curves are not exactly comparable and are given simply to show the variation in the values of latent heat as given in the tables now in use.

TABLE 1 SUMMARY OF VARIOUS DETERMINATIONS OF THE LATENT HEAT OF VAPORIZATION

Temperature, Deg. Cent.	Cal. per Kg.	Temperature, Deg. Fahr.	B.t.u.	Authority
10.90	287.0	51.62	516.6	Regnault (Jacobus)
15.53	285.2	59.95	513.3	
16.00	290.5	60.80	522.8	
12.94	283.8	55.29	510.8	
11.90	285.8	53.42	514.4	
10.73	288.1	51.31	518.5	
11.04	292.5	51.87	526.4	
10.15	292.4	50.27	526.2	
9.52	295.0	49.14	531.0	
10.99	293.3	51.78	527.9	
12.60	291.6	54.68	524.8	
7.80	291.8	46.04	525.2	
7.80	294.2	46.04	529.5	Regnault (Dieterici)
11.00	291.3	51.80	524.3	
16.00	297.4	60.80	535.3	
19.53	296.5	67.15	533.7	Von Strombeck
17.00	296.8	62.60	534.2	
−33.64	337.0	−28.55	606.6	Franklin and Kraus
−33.40	321.3	−28.12	578.3	Estreicher and Schnerr
.....	.....	84.6	524.8	Denton and Jacobus
.....	.....	82.7	525.7	
.....	.....	87.7	512.4	
.....	.....	−10.7	569.2	
.....	.....	− 3.2	603.5	
.....	.....	+14.5	570.4	

35 The equations of the curves shown in Fig. 3 are

Ledoux .... $r=583.33-0.5499t-0.0001173t^2$

Wood .... $r=555.5-0.613t-0.000219t^2$

Peabody .... $r=540-0.8\ (t-32)$

Dieterici .... $\log r=1.56141+0.5\log(266.9-t)$

Goodenough .... $\log r=1.7920+0.4\log(266-t)$

36 No comment is necessary regarding the curves for r according to Ledoux, Wood and Peabody, since their equations are not of a form such as to give correct results at high temperatures. Moreover they were derived before there were experimental determinations of the volume of the saturated vapor, from which latent heats could be calculated.

37 Dieterici used Zeuner's empirical expression for the second term of Regnault's pressure-temperature equation, and omitted the third term entirely. This approximation is quite accurate for low temperatures, but as the temperature increases the pressures thus calculated become too small, and this error increases rapidly at high temperatures. For instance, Regnault extrapolates his curve and gives for 212 deg. fahr. a pressure of 901.6 lb. per sq. in., while the value calculated by Dieterici for this temperature is 847.1 lb. per sq. in. or 6 per cent lower. As the error is increasing, the values of

$$\left[\frac{dp}{dt}\right]_{\text{sat}}$$ are too small and values of r calculated by means of the Clapeyron equation are too small at high temperatures. Since the relation employed between r and $(t_k - t)$ is a straight line on logarithmic paper and the values of $\frac{dp}{dt}$, consequently of r, agree at some

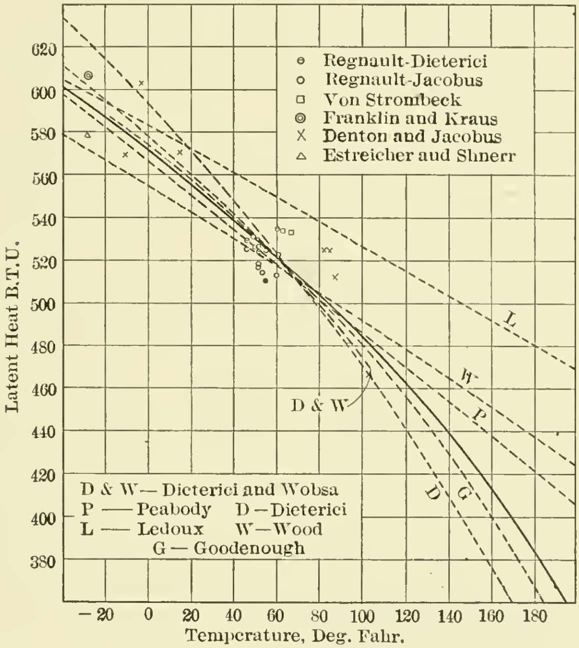

FIG. 3 CURVES SHOWING COMPARISON OF EXPERIMENTAL VALUES FOR LATENT HEAT OF VAPORIZATION WITH VALUES AS CALCULATED BY VARIOUS WRITERS

medium temperature, the values given by the equation at low temperatures will be too high. This is shown in Fig. 3, where it is seen that Dieterici's curve passes above even the highest of the actual experimental determinations of r at -28 deg. fahr.

38 The equation used by Goodenough fits the actual determinations and is consistent with the Clausius relation, using Dieterici's values for volumes and Goodenough's constants in Bertrand's pressure-temperature equation. This latter equation, however, applies over but a small temperature range. The variation between Goodenough's r curve and the present one is due to the different pressure-temperature relation used and the higher value assumed for the critical temperature.

39 It is believed that, due to the form of equation [14] and the accuracy with which it represents the derived values of r where known, the equation may be safely extrapolated as far as required in this investigation.

40 The comparison between the values of r given by equation [14], the corresponding values of v'' derived from the Clausius relation, and the experimental values for v'', properly belongs in the next section and is there shown.

41 *Specific Volume of Saturated Vapor.* The only available experimental determinations of the specific volume of the saturated vapor are those of Dieterici. These experiments extend up to a temperature of 222 deg. fahr.. but unfortunately were not carried below a temperature of 32 deg. fahr. Owing to the form of the curve representing the volume-temperature relation, any extended extrapolation of the curve or of any empirical equation to represent this relation would be very unsafe below 32 deg. fahr., where the volume is seen to increase very rapidly.

42 As shown in the preceding section, however, equation [14] is believed to be of a form such that extrapolation can be carried to very low temperatures. Therefore in the present investigation the volumes of the saturated vapor have been calculated as follows:

43 By the use of equations [12] and [13] values of $\frac{(v''-v')_a}{r_a}$ were calculated. These values multiplied by the corresponding values of r found from equation [14] gave the values of $(v''-v')$. The addition of the proper values of v' found from equation [9] gave the values of v'', the quantity desired.

44 The agreement of the values of v'' calculated by the above

method is shown in Fig. 4, the curve in this figure representing the calculated values and the points the observed values.

45 *Specific Volume of Liquid and Saturated Vapor at High Temperatures.* The "law of the straight diameter" was first proposed by

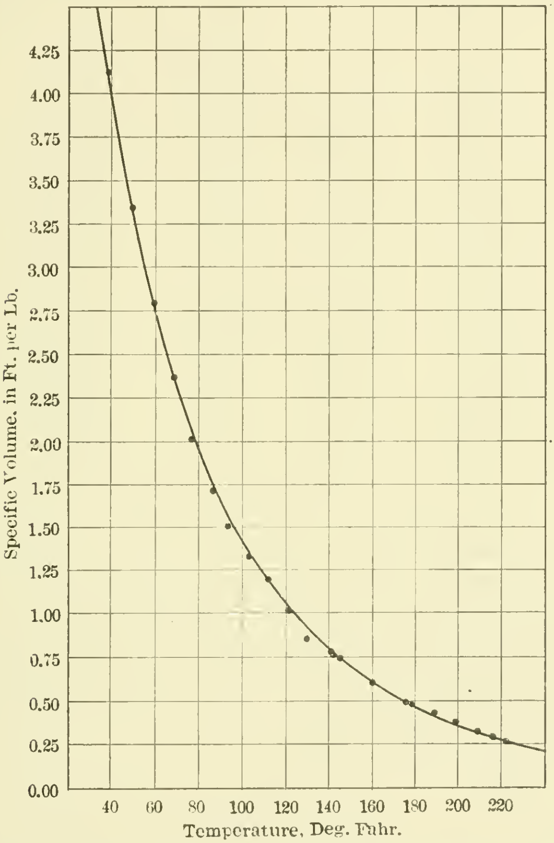

FIG. 4 CURVE SHOWING AGREEMENT OF VOLUMES OF SATURATED VAPOR AS CALCULATED WITH THOSE FOUND EXPERIMENTALLY BY DIETERICI

Cailletet and Mathias in 1886. This law, as originally given, stated that if the densities of a liquid and its saturated vapor are plotted (as abscissae) against the corresponding temperature (as ordinates) to form a dome, the mid-points of the horizontal chords of this dome will lie in a straight line nearly parallel to the axis of temperatures. References to the law may be found in an article by Davis.[1]

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[1] Proc. Am. Acad. of Arts and Sciences, vol. 45, 1910, p. 305.

TABLE 2 THE LAW OF THE STRAIGHT DIAMETER FOR AMMONIA

Temperature, Deg. Fahr.	Density of Vapor	Density of Liquid	Mean Density	By Formula	Difference
−40	0.0393	42.704	21.372	21.372	±0.000
−30	0.0517	42.296	21.174	21.174	±0.000
−20	0.0671	41.883	20.975	20.974	−0.001
−10	0.0860	41.461	20.774	20.774	±0.000
0	0.1088	41.039	20.574	20.572	−0.002
+10	0.1362	40.608	20.372	20.370	−0.002
20	0.1689	40.169	20.169	20.167	−0.002
30	0.2075	39.722	19.965	19.964	−0.001
40	0.2525	39.267	19.760	19.759	−0.001
50	0.3051	38.803	19.554	19.554	±0.000
60	0.3657	38.329	19.347	19.347	±0.000
70	0.4355	37.844	19.140	19.140	±0.000
80	0.5152	37.348	18.932	18.932	±0.000
90	0.6061	36.841	18.724	18.724	±0.000
100	0.7099	36.319	18.514	18.514	±0.000
110	0.8265	35.782	18.304	18.303	−0.001
120	0.9590	35.228	18.093	18.092	−0.001
130	1.1062	34.655	17.881	17.880	−0.001
140	1.2756	34.061	17.668	17.667	−0.001
150	1.4643	33.444	17.454	17.453	−0.001
160	1.6763	32.798	17.237	17.238	+0.001

46 It was found by Young that the diameter is actually straight in the case of all but a few substances, normal pentane being an example of this class. In the case of most substances, however, the diameter can be represented accurately by a second degree equation; some substances, such as alcohols, require a third degree equation.

47 In order to find the equation of the straight diameter for ammonia the values of the densities of the liquid and of the saturated vapor were found at 10 deg. intervals. The values for the liquid were calculated by the use of equation [9], and those for the vapor by the method described in Pars. 41–44. At each of the temperatures the mean density was calculated. The results are given in Table 2 and plotted in Fig. 5, where the points for the liquid and vapor are shown as large circles and the mean points as small circles. The diameter is seen to be slightly curved, but it may be accurately represented by the second degree equation

$$\gamma = 19.3473 - 0.02067\,(t-60) - 0.0000042\,(t-60)^2 \ldots\ldots [15]$$

The table shows that this equation represents the mean densities as calculated by the other method with a maximum error of about

1/100 of one per cent over a temperature range of −40 to +160 deg. fahr.

48 The method used at ordinary temperatures for finding the change of volume on vaporization, or $(v''-v')$, may be employed at temperatures up to the critical point if it is assumed that the values for r found by equation [14] are correct up to that point. Equation [15] gives values for

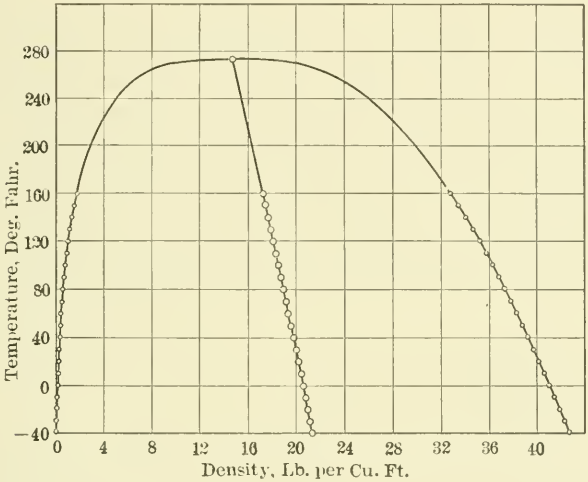

Fig. 5 Curve showing Dome of Temperature-Density Plane and "Straight Diameter" of Cailletet and Mathias

$$\frac{\gamma''+\gamma'}{2}=\frac{1}{2}\left[\frac{1}{v''}+\frac{1}{v'}\right]$$

A simple algebraic manipulation gives

$$v''=\frac{\gamma(v''-v')+1+\sqrt{\gamma^2(v''-v')^2+1}}{2\gamma}$$

Having values for v'' and $(v''-v')$, the values for v' may be easily found. This method enables the values of the volumes of the liquid and the saturated vapor to be found at least qualitatively up to the critical point itself.

49 Above 160 deg. fahr. the values found for v' by this method were materially lower than those found by equation [9] and that

the difference increased as the temperature increased above this point. An inspection of equation [9] shows that this equation would give a value of $+\infty$ for the volume of the liquid at the critical point, whereas at this point the liquid has a finite volume. In the case of other vapors it has been shown that the form of the equation used, that of Avenarius, gives accurate values at temperatures somewhat removed from the critical point, but that it does not hold near this point. Therefore, in the present case equation [9] has been used only up to 160 deg. fahr., and the values above this temperature have been calculated by the law of the straight diameter.

50 Since the diameter is nearly parallel to the axis of temperatures a considerable error in the value of the critical temperature will cause but a small error in the resulting value of the critical density. The substitution in equation [15] of the assumed value of t_k, or 273.2 deg. fahr., gives for the critical density and volume respectively

$$\gamma_k = 14.75 \text{ lb. per cu. ft.}$$
$$v_k = 0.0678 \text{ cu. ft. per lb.}$$

51 *Specific Volume of the Superheated Vapor.* The attempt has often been made to deduce rationally an equation of state which with suitable change of constants will represent the relation $f(P, v, T) = 0$ for various fluids in all states from the gaseous condition above the critical temperature to the liquid condition. Such equations are constructed with special reference to the behavior of fluids in the neighborhood of the critical state and apply more particularly to fluids, the critical temperature of which is within the range encountered in practice. In the case of a fluid such as ammonia, however, the critical temperature of which is far above the working range, purely empirical equations of simpler form give better results throughout the small range covered in practice, and in addition lend themselves much more readily to the formation of the various heat equations. Of these equations those of Ledoux, Zeuner, Peabody and Wood were based upon various doubtful assumptions, while Wobsa's first equation gives values that do not closely agree with experimental results, and only his second equation

$$v - a = \frac{BT}{p} - \frac{c}{T^n} + \frac{b}{p} \qquad [16]$$

with

$B = 49.736$
$a = 0.0075$
$C = 2450$
$n = 2$
$b = 80$

is quite satisfactory in this respect.

52 In choosing a characteristic equation several points must be considered.

- *a* The equation must represent with fair accuracy the available reliable experimental data on the relations of p, v and T.
- *b* The equation should be of a form such as to make the various thermodynamic relations derived from it as simple as possible.
- *c* These derived equations must represent accurately the experimental data.

53 Wobsa's second equation fulfils the first of these conditions admirably. It is, however, somewhat defective with respect to the other requirements. The good results obtained from Goodenough's equation for superheated steam

$$v+c=\frac{BT}{p}-(1+ap)\frac{m}{T^n} \qquad [17]$$

suggested the adoption of the same form of equation for superheated ammonia in the preliminary investigation. This equation satisfies the second condition in that it gives derived relations of comparatively simple form. A trial with various sets of constants showed that it could be made to represent the volume measurements substantially with the same accuracy as Wobsa's second equation, and thereby satisfy the first condition. Having established the fact that the proposed equation is permissible, the next step was the determination of the constants. In connection with this process emphasis must be placed on the third consideration heretofore mentioned. From the characteristic equation are derived expressions for (*a*) the specific heat at constant pressure; (*b*) the heat content of the superheated and also of the saturated vapor; (*c*) the Joule-Thompson coefficient. Hence the constants must be chosen not with reference to volume alone. While the volume measurements must be satisfied, three other derived relations must conform equally well to the experimental data in the respective fields.

54 With due consideration of all the conditions the following values were finally assumed for the constants:

$B=0.6321$, p in lb. per sq. in.
$\log m=12.900000$
$c=0.100$
$n=5$
$a=0$

The final equation with constants inserted is therefore

$$v+0.100=0.6321\frac{T}{p}-\frac{79433\times10^{8}}{T^{5}}\ldots\ldots\ldots\ldots[18]$$

55 It will be seen that the constant a is taken as zero. In view of the fact that the available data consist only of values along the saturation curve and in most cases but one point on each isotherm in the superheated region, no information is available regarding the shape or curvature of these isotherms on the $pv-p$ plane; moreover the derived equations demand an exceedingly small value of a. The use of straight lines for these isotherms therefore seems to be as well justified as the use of parabolas; hence a was made equal to zero.

56 A summary of the various direct determinations of the specific volume of the superheated vapor according to Perman and Davies and LeDuc and Guye is given in Table 3. In Table 4 the values given by equation [18] and by Wobsa's first and second equations are compared with these experimental determinations. It is seen that both equation [18] and Wobsa's second equation give results agreeing better with experiment at the one atmosphere points than those obtained from Wobsa's first equation. At the 32, 122 and 212 deg. fahr. points at one atmosphere pressure equation [18] and Wobsa's second equation give practically the same percentage deviation from the experimental values. At −4 deg. Wobsa's second equation gives a better agreement with the experimental value than does equation [18]; this point, however, is considerably below the range found for superheated ammonia in practice, and it is believed that the considerations appearing in the discussion of the heat equations derived from the characteristic equation justify the use of equation [18] in preference to Wobsa's equations.

57 In Fig. 6 the isotherms deduced from equation [18] are drawn on the $pv-p$ plane and the various experimental points are plotted

in order to show the agreement. From this chart it is seen that if both of the determinations of Perman and Davies at 32 deg. are correct, the one at one atmosphere and the other at one-half atmosphere, then either the saturation curve should lie considerably higher or the 32 deg. isotherm should be sharply curved. Since the one atmosphere determination agrees closely with the determinations of LeDuc and Guye, since there is good authority for the location of the saturation curve, and since the flatness of the isotherms is fairly well established, it would seem that the half atmosphere point of Perman and Davies is probably in error.

TABLE 3 SUMMARY OF VARIOUS DETERMINATIONS OF VOLUME OF THE SUPERHEATED VAPOR

Pressure, Atmos.	Temperature, Deg. Cent.	Volume in Liters per Gram	Temperature, Deg. Fahr.	Volume, Cu. Ft. per Lb.	Authority
1/2	0	2.6096	32	41.8006	Perman
1	−20	1.19575	−4	19.1535	
	0	1.2973	32	20.7802	
	50	1.5473	122	24.7847	
	100	1.7964	212	28.7747	
	0	1.2955	32	20.7513	Le Duc
	0	1.2974	32	20.7818	Guye

TABLE 4 COMPARISON OF VALUES OBTAINED FROM VARIOUS EQUATIONS FOR VOLUME OF SUPERHEATED VAPOR WITH EXPERIMENTAL VALUES

Pressure, Atmos.	Temperature, Deg. Fahr.	Experimental Values		Computed from 18		Computed by Wobsa I		Computed by Wobsa II	
		Authority	Value	Value	% Diff. from Exp.	Value	% Diff. from Exp.	Value	% Diff. from Exp.
1	−4	Perman	19.154	19.093	−0.32	19.121	−0.17	19.140	−0.07
	32	Perman	20.780	20.769	−0.05	20.745	−0.17	20.767	−0.06
		Guye	20.782	20.769	−0.06	20.745	−0.18	20.767	−0.07
		Le Duc	20.751	20.769	+0.09	20.745	−0.03	20.767	+0.08
	122	Perman	24.785	24.798	+0.05	24.746	−0.16	24.775	−0.004
	212	Perman	28.775	28.730	−0.16	28.695	−0.28	28.725	−0.17
1/2	32	Perman	41.801	41.916	+0.28	41.821	+0.05	41.939	+0.33

58 In Fig. 6 the full line curve represents values resulting from equation [18] and the dotted line curve represents the values resulting from equation [15]. A comparison of Wobsa's equations is not given because the constants in those equations were determined on the assumption of a different pressure-temperature relation along the saturation curve; the substitution in Wobsa's equations of the values of pressure corresponding to given temperatures as used in this investigation would not therefore give values of volume comparable with those deduced from equation [18]. It may be stated, however, that Wobsa's equations give very fair agreement with the values found experimentally by Dieterici, the maximum deviation of the second equation from the values given in Dieterici's table being a little over 2 per cent.

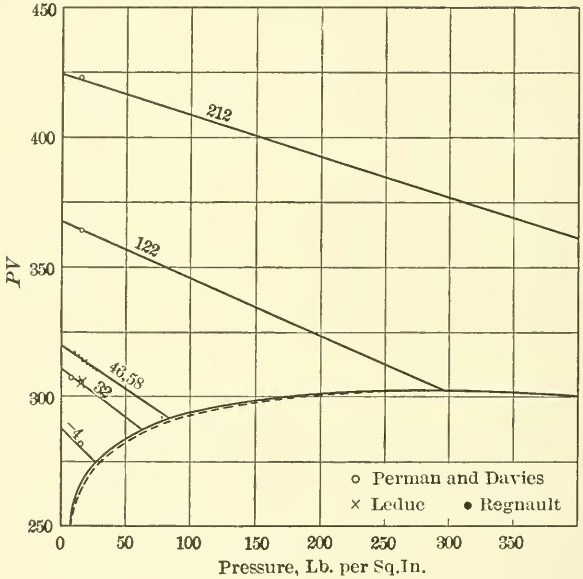

Fig. 6 Comparison of Isotherms deduced from Equation [18] with Points representing Experimental Determinations shown on $PV-P$ Plane

59 In addition to the preceding the only data available for the purpose of checking the characteristic equation are the results of a series of experiments performed by Regnault. In these experiments measurements were made of the relative volumes occupied by a

quantity of ammonia gas at different pressures along the isotherm corresponding to a temperature of 8.1 deg. cent. or 46.58 deg. fahr. As the weight of ammonia used was not recorded, the experiments can only be used to obtain the relative values of the specific volume or of the product pv along this isotherm. In making use of these values the products pv were plotted against the corresponding values of p, both quantities being measured in the units employed by Regnault. A straight line was next passed through these points by the method of least squares. It was found that the pressure equivalent to 20 lb. per sq. in. came at about the center of the group of points, and the value of the specific volume was calculated by equation [18] for this pressure and a temperature of 46.58 deg. fahr.; this value multiplied by the pressure gave a value of the product pv in English units. The value of this product in the units used by Regnault was then found at the point where the straight line determined by least squares crossed the pressure coördinate equivalent to a pressure of 20 lb. per sq. in. From these two values for pv the conversion factor 0.00561 was found, this being the number by which Regnault's values of pv must be multiplied in order that the isotherm calculated from equation [18] shall pass through the center of Regnault's group of points. All of his values of pv were multiplied by this factor and the points plotted in Fig. 6 as small black dots. The only information they afford is a check on the slope of the isotherm for 46.58 deg. fahr. on the $pv-p$ plane. The points seem to indicate that the isotherms near this temperature at least, are very flat curves or even straight lines.

60 *Specific Heat of the Superheated Vapor.* The first determination of the specific heat of superheated ammonia was made by Regnault, who found a value of 0.50836 at atmospheric pressure and over a temperature range of 75 deg. fahr. to 420 deg. fahr. Later Wiedemann performed two series of experiments at a pressure of about 16 lb. per sq. in.; he found a value of 0.5202 between 77 and 212 deg. fahr. and a value of 0.5356 between 77 and 392 deg. fahr. He proposed the equation

$$c_p = 0.4949 + 0.000172t$$

61 Thus far the history is much the same as in the case of superheated steam, the specific heat of which was long supposed to be independent of both temperature and pressure and equal to 0.48 as determined by Regnault; later the investigations of Maillard and LeChatelier and of Lange agreed in making it a linear function of

the temperature. In the case of steam, however, the experiments of Knoblauch and Jakob, Thomas, and Knoblauch and Mollier have shown that the specific heat of superheated steam depends upon the pressure. While no experiments have been made to investigate the variation of the specific heat of superheated ammonia with pressure, it is very probable that there is such a variation and its rate may be determined by means of Clausius' thermodynamic relation providing a sufficiently accurate characteristic equation has been determined. The process of obtaining an explicit expression for c_p in terms of the variables p and T has inherent difficulties and is rendered more difficult in this case by the meagerness of the data available. The success with which the method has been applied to superheated steam by Goodenough, however, seems to warrant its use in the present investigation.

62 The application of the Clausius relation to equation [18] readily gives the following equation for c_p:

$$c_p = \phi(T) + \frac{Amn(n+1)}{T^{n+1}} p \quad \ldots\ldots\ldots\ldots\ldots [19]$$

For the complete derivation of this equation see Appendix No. 2.

63 If the arbitrary function $\phi(T)$ can be determined, there will result an explicit expression for c_p in terms of the variables p and T. Wobsa has used the same method of analysis starting with his own characteristic equations and has obtained equations for c_p similar to the present one.

64 The determination of the proper function $\phi(T)$ is the critical point of the investigation. Wobsa equated his expression for c_p at atmospheric pressure to Wiedemann's linear equation for c_p at atmospheric pressure and thus found the $\phi(T)$ to be of the form

$$\phi(T) = a + bt - \frac{c}{T^3}$$

He shows that the terms in the third power of T, which is the correction term for atmospheric pressure, is vanishingly small above 212 deg. fahr. and that above this temperature c_p at infinitely small pressures will not differ from c_p at atmospheric pressure, or $\phi(T) = 0.4949 + 0.000172t$. Below 212 deg. fahr. where the correction term becomes appreciable, Wobsa substitutes the linear function $\phi(T) = 0.4712 + 0.000278t$.

65 For the determination of ϕ (T) in the present investigation there are available the recent determinations of c_p at high temperatures by Nernst. In addition to the results of his own work, Nernst gives a summary of the results of previous investigations (see Table 5). In this table the values are given as molecular specific heats and these have been converted into specific heats per unit of weight by dividing by the molecular weight of NH_3 or 17.064. It is seen that the values given for Wiedemann are lower than those quoted earlier in this section from the original; while the value given for Regnault is higher than the original. As the original papers of Keutel and Voller are not at hand the values given in this table for their results are assumed to be correct, but the values used for Wiedemann and Regnault are those taken from the original.

TABLE 5 SUMMARY OF C_p MEASUREMENTS AS GIVEN BY NERNST

Temperature, Deg. Cent.	Molecular C_p	Temperature, Deg. Fahr.	C_p	Authority
20	8.64	68	0.506	Keutel
20	8.62	68	0.505	Voller
25–100	8.84	77–212	0.518	E. Wiedemann
25–200	9.11	77–392	0.534	E. Wiedemann
24–216	8.71	75–421	0.510	Regnault
365–567	10.4	689–1053	0.609	Nernst
480–680	11.2	896–1256	0.656	Nernst

66 If in the equation for c_p, $p=0$, the equation reduces to $c_p=\phi$ (T). Therefore if we have values for c_p at zero pressure the ϕ (T) may be determined. To obtain these values the proper correction terms were calculated and subtracted from the values of c_p. The resulting values of $(c_p)_o$ seemed to justify the assumption that $(c_p)_o$ is a linear function of the temperature. This linear relation may not, and probably does not, hold for the entire range of superheat, but it may be assumed as a close approximation, and is the only assumption justified by the experimental data available. The function therefore takes the simple form

$$\phi\ (T)=\alpha+\beta T$$

and the equation for c_p becomes

$$c_p=\alpha+\beta T+\frac{Amn\ (n+1)}{T^{n+1}}p \ldots\ldots\ldots\ldots\ldots [20]$$

67 The constants m and n are those heretofore given in connection with the characteristic equation, and the values finally chosen for α and β are: $\alpha=0.382$; $\beta=0.000174$. Replacing $Amn\ (n+1)$ by a single constant C, and substituting the proper value for the various constants the formula for the specific heat becomes:

$$C_p=0.382+0.000174\,T+p\frac{C}{T^6}\cdots\cdots\cdots\cdots[21]$$

where $\log C=13.644705$.

68 Values of c_p have been calculated for various pressures up to 400 lb. per sq. in. and for temperatures up to 1100 deg. fahr.; these values are plotted against temperatures in Fig. 7. The experimental determinations are also plotted to show the agreement. The determinations of Regnault, Nernst, Keutel and Voller were made at atmospheric pressure, while those of Wiedemann were at a pressure of about 16 lb. per sq. in. absolute. The agreement between the curve derived from equation [21] for a pressure of 15 lb. per sq. in. and the points representing the determinations of Regnault, Nernst, Keutel and Voller is seen to be very good, while the points representing Wiedemann's determinations lie considerably above the curve.

69 *Heat Content of Saturated and Superheated Vapor.* Having an explicit formula for the specific heat at constant pressure in terms of the variables p and T, an expression for the heat content in terms of these variables may be easily derived:

$$i=\alpha T+\frac{\beta}{2}T^2-A(n+1)p\frac{m}{T^n}-Acp+i_0\ldots\ldots\ldots\ldots[22]$$

For complete derivation of this formula, see Appendix No. 3.

70 The constant of integration i_0 is determined by passing to the saturation limit. Since the constants α, β, m, n and c are known, the value of the right-hand member of equation [22], exclusive of i_0 may be found for any given pressure and temperature. If the value of i is known at this point, i_0 may be determined by subtraction. Now for the saturated vapor

$$i''=i'+r=u+Apv'+r$$

If the energy u be taken equal to zero at 32 deg. fahr., then at this temperature

$$i''_{32}=0+Ap_{32}v'_{32}+r_{32}$$

Substituting the proper values as determined by the formulae for the saturated vapor there results

$$i''_{32}=0.3+546.4=546.7$$

By the substitution of the proper values of p and T in equation [22] there results

$$i=i_{o}=188.7$$

$$\text{By subtraction } i_{o}=358.0$$

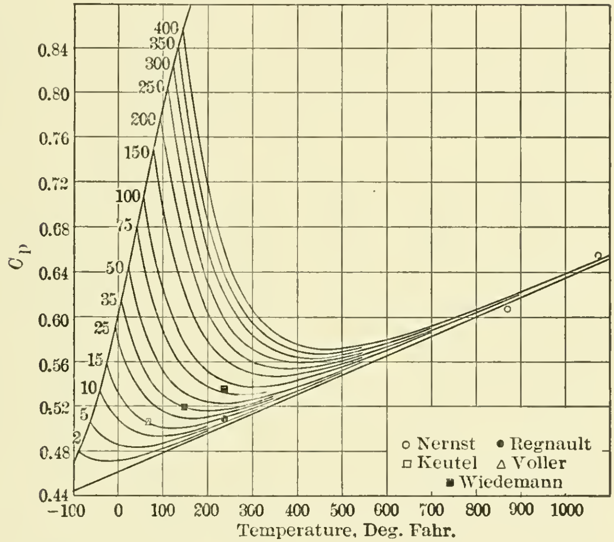

FIG. 7 CURVES GIVING VALUES OF SPECIFIC HEAT AT CONSTANT PRESSURE

Introducing known constants equation [22] becomes, with pressure in lb. per sq. in.

$$i=0.382T+0.000087T^{2}-p\frac{C}{T^{5}}-0.0185p+358.0\ldots\ldots[23]$$

where $\log C=12.945735$.

71 There are no direct measurements of the total heat or heat content of the superheated or saturated vapor by which equation [23] may be checked. A check on the accuracy of the equation at the saturation limit is afforded by a comparison of the values of the heat content of the liquid, obtained by subtracting values of r calculated by equation [14] from values of i'' calculated by equation

[23], with the experimental determinations of Dieterici. This comparison is shown in the following section. A check on the accuracy of the formula in the superheated region may be obtained by a comparison, by means of the law of corresponding states, of the values for the Joule-Thompson coefficient resulting from equation [23] with the values of this coefficient for other vapors. There is also available a set of throttling experiments performed by Wobsa. This check is given in Appendix No. 4 and Fig. 10.

TABLE 6 HEAT CONTENT OF LIQUID AS DEDUCED FROM EXPERIMENTS OF DIETERICI AND DREWES

C'_{im} (t − 0° C)	u' Above 0°C. Cal. of 4.222 Joules	u' Above 0°C. Cal. of 4.184 Joules	Temperature, Deg. Cent.	Temperature, Deg. Fahr.	u' Above 32° F. in B.t.u.	$i' = u' + Apv'$	Authority
1.148	10.65	10.75	9.28	48.70	13.95	19.77	Dieterici
1.162	10.93	11.03	9.41	48.94	19.85	20.27	
1.141	24.25	24.47	21.25	70.25	44.04	44.67	
1.140	24.57	24.79	21.55	70.79	44.62	45.26	
1.139	38.67	39.02	33.95	93.11	70.23	71.21	
1.147	39.27	39.62	34.24	93.63	71.31	72.30	
1.200	42.03	42.41	35.02	95.03	76.34	77.35	
1.172	48.17	48.60	41.1	105.96	87.46	88.68	Drewes,—reliable according to Dieterici
1.158	48.35	48.78	41.75	107.15	87.78	89.02	
1.186	61.44	62.00	51.8	125.22	111.60	113.25	
1.163	60.42	60.97	51.95	125.46	109.75	111.41	
1.187	70.74	71.38	59.6	139.3	128.50	130.57	
1.164	72.75	73.41	62.5	144.5	132.15	134.40	
1.179	82.76	83.50	70.2	158.4	150.30	153.07	
1.205	87.48	88.27	72.6	162.7	158.90	161.84	
0.974	11.50	11.60	11.8	53.24	20.89	21.35	Drewes,—questioned by Dieterici
1.098	21.62	21.81	19.7	67.46	39.26	39.86	
1.069	22.82	23.02	21.35	70.43	41.44	42.08	
1.140	34.61	34.92	30.36	86.64	62.85	63.72	
1.148	35.83	36.16	31.21	88.17	65.08	65.97	
0.7065	−10.49	−10.59	−14.85	5.27	−19.06	−18.91	

72 *Heat Content of the Liquid.* The values of heat content of the liquid may be found by subtracting the values of r found by equation [14] from the values of i'' found by equation [23]. The most important check on these values is derived from a series of experiments performed by Dieterici and by Drewes working in Dieterici's laboratory. In these experiments the quantity measured was the amount of heat given up by a certain weight of a mixture of saturated and liquid ammonia cooling at constant volume in a sealed tube.

This quantity was corrected for the heat due to the latent heat of the portion of vapor condensed and the remaining amount of heat was divided by the change in temperature to obtain the mean "inner" specific heat of the liquid over that temperature range. In his paper Dieterici gives only the formula which he chose as best representing the results of his experiments, which states that the mean "inner" specific heat between t and 32 deg. fahr. $= 1.118 + 0.000578\ (t - 32)$. Since this is a linear function of the temperature it follows that the instantaneous "inner" specific heat $= 1.118 + 0.001176\ (t - 32)$. The original data of the experiments are not given, but Professor Dieterici has kindly furnished the values which he actually obtained for the mean "inner" specific heat and also a copy of Mr. Drewes' dissertation containing the values obtained by him. If each of these values of the mean "inner" specific heat is multiplied by the temperature

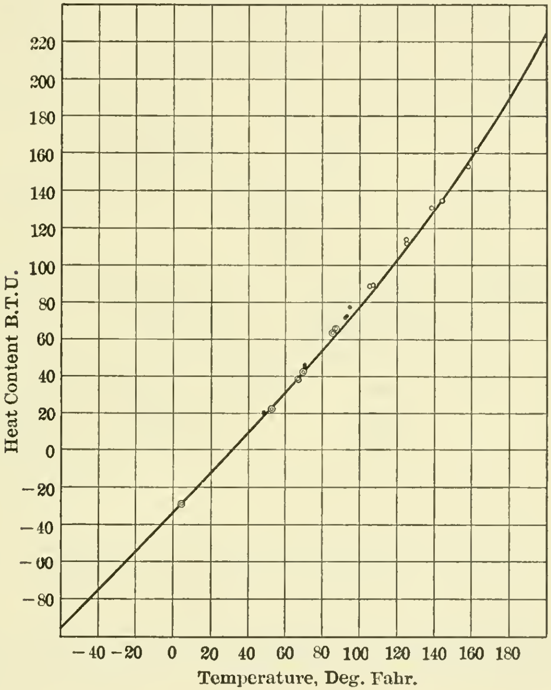

FIG. 8 COMPARISON OF CALCULATED VALUES OF HEAT CONTENT OF LIQUID WITH VALUES DEDUCED FROM EXPERIMENTAL WORK OF DIETERICI AND DREWES

range covered the result will be approximately equal to the internal energy u above 32 deg. fahr. at the temperature t. Since $i' = u' + Apv'$, in order to obtain values of i' the product Apv' corresponding to the temperature t must be added to the value of u' obtained as described. The results of these calculations appear in Table 6. Since Dieterici reported his results in terms of a mean calorie equal to 4.222 joules while in the present investigation a mean calorie of 4.184 joules is used, all of Dieterici's heat quantities must be multiplied by 1.009. The table includes the determinations made by Dieterici himself and all of the determinations made by Drewes; part of the latter are called reliable by Dieterici, while the rest are marked "falsch" in the copy of Drewes' dissertation loaned by Dieterici. The ground for this statement is not given. In Fig. 8 Dieterici's values are plotted as black dots, and those of Drewes as circles. The values questioned by Dieterici are indicated by double circles. The curve represents the values found by the use of equations [14] and [23]. It is seen that in several cases the curve passes between the Dieterici points and the doubtful Drewes points.

TABLE 7 SUMMARY OF DETERMINATIONS OF THE SPECIFIC HEAT OF LIQUID AMMONIA

Temperature, Deg. Cent.	Temperature, Deg. Fahr.	Specific Heat of Liquid	Authority
62–30	144–86	1.22876	von Strombeck
20–0	68–32	1.02	Elleau and Ennis
77.7	139.9	0.886	Ludeking and Starr
20–16	68–61	1.094	A. J. Wood

73 Since the quotient obtained by dividing the change in i' between two temperatures by the difference in temperature is very nearly equal to the specific heat, the other determinations which have been made of the specific heat may be used to check the calculated values of i'. Table 7 contains a summary of the determinations of the specific heat of the liquid in addition to the work of Dieterici and Drewes already given; this includes the work of Elleau and Ennis, von Strombeck, Ludeking and Starr and A. J. Wood. In Fig. 9 these values are plotted, together with the curves representing the following equations used in the computation of various tables:

Dieterici	$c'=1.118+0.001156\ (t-32)$
Zeuner	$c'=1.01235+0.00468\ (t-32)$
Wood	$c'=1.12136+0.000438t$
Ledoux	$c'=1.0058+0.0020322\ (t-32)$
Elleau and Ennis	$c'=0.9834+0.0020322\ (t-32)$
Peabody	$c'=1.1$ constant

74 The full line curve represents the values of the tangents to the heat content curve of the present investigation. Since according to modern ideas of the critical point the specific heat of the liquid there becomes equal to plus infinity, the full line curve is of a more rational form than any linear relation.

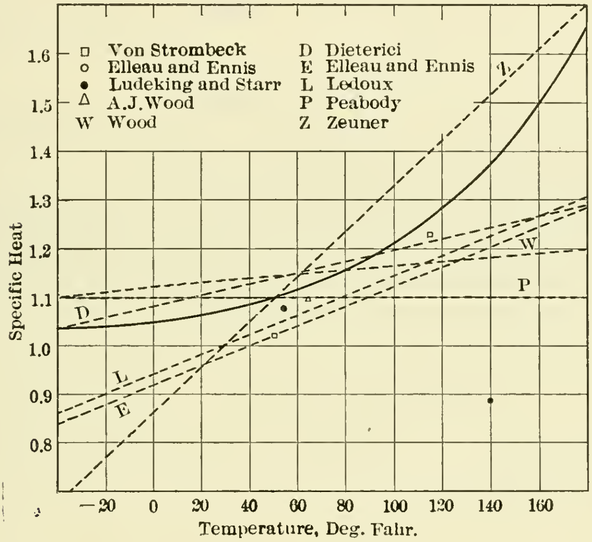

FIG. 9 COMPARISON OF VARIOUS DETERMINATIONS OF SPECIFIC HEAT OF LIQUID AND VARIOUS EQUATIONS PROPOSED TO REPRESENT SAME QUANTITY

75 *Entropy of the Saturated and Superheated Vapor.* An expression for the entropy is readily derived from the characteristic equation and the expression for c_p:

$$s=\alpha \log_e T+\beta T-AB \log_e p-Anp\frac{m}{T^{n+1}}+S_o \ldots\ldots\ldots [24]$$

For the complete derivation of this equation, see Appendix No. 3.

76 The constant s_0 is determined by passing to the saturation limit at 32 deg. fahr., where $s'=0$ and therefore $s''=\frac{r}{T}$. Substituting this value for s in the left-hand member of equation (s) and the proper values of p and T in the right-hand member, s_0 is found to be equal to -0.82656. Substituting this value and the known values of the other constants, and passing to common logarithms equation [24] becomes

$$s=0.8796 \log T+0.000174\,T-0.2695 \log p-\frac{p}{T^6}C-0.82656 \qquad [25]$$

where $\log C=12.866554$.

ACKNOWLEDGMENT

77 Acknowledgment is hereby made to Prof. G. A. Goodenough of the University of Illinois, who suggested this investigation and who has given to it his hearty encouragement and his personal supervision.

78 The investigation was made under the auspices of the mechanical engineering department of the Engineering Experiment Station of the University of Illinois, and complete tables based upon the formulae set forth in this paper, together with a Mollier diagram and a full bibliography of the subject will in due time be published as a bulletin of the station.

APPENDIX No. 1

METHOD OF CONSTRUCTION OF FIG. 1

79 Using formula [7] to obtain the saturation temperatures of ammonia from those of water

$$\frac{1}{T_a}=c\frac{1}{T_w}+k$$

Let

$$\frac{-1}{T_w}=y \quad \text{and} \quad \frac{-1}{T_a}=x$$

then

$$-x=-cy+k$$

Since y is a function of the water vapor temperature corresponding to pressure p, y is also a function of p; the value of y for a given value of p may be found by making use of the tables of water vapor pressure; x is a function of the temperature of the ammonia corresponding to this same vapor pressure p; the curve giving x as a function of y is evidently a straight line.

80 Since y is a function of the pressure p and x a function of the corresponding temperature, the values of x and y may represent their respective values of pressure and temperature. The corresponding values of saturation temperature and vapor pressure may be read directly from the diagram.

81 Fig. 1 was constructed in the following manner: Integral values of temperature were assumed and the corresponding values of x were computed according to the relation $x=-\frac{1}{T}\cdot$ These x's were then laid off to a convenient scale and each labeled with the temperature to which the value of x corresponds. Integral values of pressure were assumed, the corresponding values of temperature found from steam tables, and the corresponding values of y computed according to the relation $y=-\frac{1}{T}$. These y's were then laid off to a convenient scale and each labeled with the pressure to which the value of y corresponds.

82 The value of vapor pressure at a given temperature as taken from the Marks and Davis steam tables was found to agree with the value given by the new Marks formula with sufficient accuracy up to a temperature of 400 deg. fahr.; above this temperature the values differed materially. In the construction of the chart, therefore, the steam tables were used to find the pressures corresponding to temperatures below 400 deg. fahr. and the newer formula was used to find the pressures corresponding to temperatures above that point.

83 Table 8 shows the calculations for a few of the values of Fig. 1.

84 In order to settle upon the most probable location of the straight line representing the pressure-temperature relation of saturated ammonia upon this

TABLE 8 SAMPLE CALCULATIONS OF THE COÖRDINATES OF FIG. 1

ABSCISSAE

Temperature, Deg. Fahr.	Absolute Temperature	Reciprocal of Absolute Temperature	Corresponding Value of X, In., referred to the point −10 as Origin $= -(8000 \times \pm -10)$
−100	359.64	0.0027806	12.244
−50	409.64	0.0024412	9.529
0	459.64	0.0021756	7.405
+50	509.64	0.0019622	5.697
100	559.64	0.0017869	4.295
150	609.64	0.0016403	3.122
200	659.64	0.0015160	2.128
250	709.64	0.0014092	1.273

ORDINATES

Pressure, Lb. per Sq. In.	Corresponding Saturation Temperature of Water Vapor, Deg. Fahr.	Absolute Temperature	Reciprocal of Absolute Temperature	Corresponding Value of y, In., referred to the point −18 as Origin $= -(20000 \times \pm -18)$
1	101.83	561.47	0.0017810	17.621
5	162.28	621.92	0.0016079	14.158
10	193.22	652.86	0.0015317	12.634
50	281.0	740.64	0.0013502	9.004
100	327.8	787.44	0.0012699	7.399
500	467.2	926.84	0.0010789	3.579
1000	544.9	1004.54	0.0009955	1.910
1700	613.4	1073.04	0.0009319	0.639

TABLE 9 SUMMARY OF DETERMINATIONS OF CRITICAL DATA FOR AMMONIA

Investigator	Date	Temperature, Deg. Cent.	Pressure, Atmospheres	Temperature, Deg. Fahr.	Pressure, Lb. per Sq. In.
Dewar.........	1884	130.0	115	266.0	1690.0
Vincent and Chappuis..	1886	131.0	113	267.8	166.08
Jaquerod.......	1908	132.3	109.6	270.1	1610.7
Sheffer.........	1910	132.1	111.3	269.8	1635.7

chart the experimental data must be plotted. The pressures observed by Pictet over a temperature range of -22 to 122 deg. fahr. agree almost exactly with those observed by Regnault; they are neither tabulated nor plotted. Faraday's results are quite inconsistent with those of Regnault, and are neither plotted in Fig. 1 nor given weight in the determination of the constants of the equation.

85 The two points in the upper right-hand corner of Fig. 1 represent the experiments at the critical point. The open square shows the values given by Vincent and Chappuis and the solid triangle the values given by Dewar. The values from which these points were plotted are given in Table 9.

86 This table also contains the values for critical data given by Jaquerod and Scheffer, which were found after the plate for Fig. 1 was made.

APPENDIX No. 2

DERIVATION OF EQUATION [19]

$$c_p = \phi T + \frac{Amn\ (n+1)}{T^{n+1}} p$$

87 The Clausius relation is expressed by the equation

$$\left[\frac{\partial c_p}{\partial p}\right]_T = -AT\left[\frac{\partial^2 v}{\partial T^2}\right]_p$$

The derivative in the right-hand member is determined from the characteristic equation. Thus from equation [18]

$$\frac{\partial v}{\partial T} = \frac{B}{p} + \frac{mn}{T^{n+1}} \dots\dots\dots [26]$$

and

$$\frac{\partial^2 v}{\partial T^2} = -\frac{mn\ (n+1)}{T^{n+2}} \dots\dots\dots [27]$$

Substituting the second derivative in the Clausius relation the result is

$$\left[\frac{\partial c_p}{\partial p}\right]_T = \frac{Amn\ (n+1)}{T^{n+1}} \dots\dots\dots [28]$$

Taking T as a constant and integrating with respect to p as the independent variable, the result is

$$c_p = \frac{Amn\ (n+1)}{T^{n+1}} p + \text{constant of integration}$$

The constant of integration may be a function of T, since T was held constant during the integration; hence

$$c_p = \phi\ (T) + \frac{Amn\ (n+1)}{T^{n+1}} p \dots\dots\dots [29]$$

APPENDIX No. 3

DERIVATION OF EQUATIONS [22] AND [24]

$$i=\alpha T+\frac{\beta T^2}{2}-A\ (n+1)\ p\,\frac{m}{T^n}-Ac_p+i_o$$

$$s=\alpha\ \log_e T+\beta T-AB\ \log_e p-Anp\ \frac{m}{T^{n+1}}+s_c$$

88 Having an explicit formula for the specific heat at constant pressure in terms of the variables p and T, an expression for the heat content in terms of these variables may be easily derived. For this purpose the general equation

$$dq=c_p dT-AT\left[\frac{\partial v}{\partial T}\right]_p dp\ldots\ldots\ldots\ldots\ldots\ldots[30]$$

is most convenient. Since the heat content is defined by the relation

$$i=A\ (u+pv)$$

then

$$di=A\ [du+d(pv)]$$

or

$$di=dq+Avdp$$

Hence by substitution in equation [30] there results

$$di=c_p dT-A\left[T\frac{\partial v}{\partial T}-v\right]dp\ldots\ldots\ldots\ldots\ldots\ldots[31]$$

From the characteristic equation

$$\frac{\partial v}{\partial T}=\frac{B}{p}+\frac{nm}{T^{n+1}}$$

whence

$$T\frac{\partial v}{\partial T}-v=(n+1)\ \frac{m}{T^n}$$

Substituting this and the general expression for c_p in equation [31] the result is

$$di=(\alpha+\beta T)\ dT+Amn\ (n+1)\ p\frac{dT}{T^{n+1}}-\frac{Am\ (n+1)}{T^n}\ dp-Acdp\ldots\ldots[32]$$

Since i depends upon the state of the substance only, the second member of equation [30] must be an exact differential. The integral is readily found to be

$$i = \alpha T + \frac{\beta}{2} T^2 - A(n+1)\frac{pm}{T^n} - Acp + i_0 \ldots\ldots\ldots\ldots [33]$$

89 An expression for entropy is readily found from equation [30]. Thus

$$ds = \frac{dq}{T} = c_p \frac{dT}{T} - A\left[\frac{\partial v}{\partial T}\right]_p dp \ldots\ldots\ldots\ldots [34]$$

Introducing in equation [34] the expressions previously derived for c_p and $\left[\frac{\partial v}{\partial T}\right]_p$, the result is

$$ds = \left[\frac{\alpha}{T} + \beta\right] dT + Amn\,(n+1)p\frac{dT}{T^{n+2}} - \frac{ABdp}{p} - \frac{Amn}{T^{n+1}}dp \ldots\ldots\ldots [35]$$

The integral of equation [35] is

$$s = \alpha \log_e T + \beta T - AB \log_e p - Anp\frac{m}{T^{n+1}} + s_0 \ldots\ldots\ldots\ldots [36]$$

APPENDIX No. 4

TEST OF VALIDITY OF EQUATION [23] BY MEANS OF THE LAW OF CORRESPONDING STATES

90 Since i is constant in a throttling process, the Joule-Thompson coefficient μ may be defined as the derivative

$$\left[\frac{\partial T}{\partial p}\right]_{i}$$

From calculus

$$\left[\frac{\partial T}{\partial p}\right]_{i} = -\frac{\dfrac{\partial i}{\partial p}}{\dfrac{\partial i}{\partial T}}$$

and from the definition of heat content i

$$\frac{\partial i}{\partial T} = c_{p}$$

Hence

$$\mu = \left[\frac{\partial T}{\partial p}\right]_{i} = -\frac{1}{c_{p}} \cdot \frac{i}{p}$$

or

$$\mu = \frac{A}{c_{p}}\left[\frac{m\ (n+1)}{T^{n}} + c\right] \qquad \text{..................[37]}$$

91 From equation [37] it is seen that μ varies with the pressure; as the temperature rises, however, the influence of pressure decreases. Joule and Kelvin, working with gases far removed from the saturation limit, found that μ varies inversely as the square of the absolute temperature. The experimental values of μ for steam expressed in pounds per square inch and degrees fahrenheit were reduced by multiplying by 2.56, a factor which is the ratio of the critical pressure of water (2947 lb. per sq. in.) to the critical temperature (1149 deg. fahr.), these critical values being the ones determined by Cailletet and Colardeau. Davis gives a curve which he says represents the experimental values for water in the best possible manner; the values in this curve are those translated back to ordinary units. Later determination of the critical constants for water by

Holborn and Bauman give 3200 lb. per sq. in. for the critical pressure and 1166 deg. fahr. for the critical temperature Table 10. If then the values of μ on the

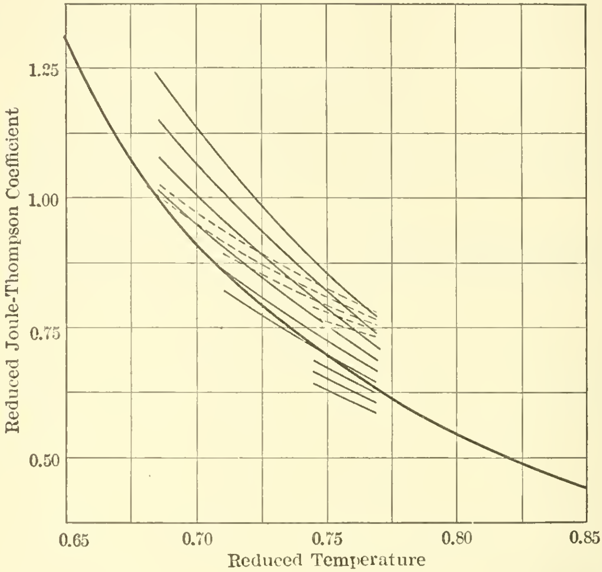

FIG. 10 COMPARISON OF VALUES OF REDUCED JOULE-THOMPSON COEFFICIENT FOR AMMONIA ACCORDING TO WOBSA AND VALUES RESULTING FROM EQUATION (p) WITH VALUES FOR WATER AS GIVEN BY DAVIS

TABLE 10 SUMMARY OF DETERMINATIONS OF CRITICAL DATA FOR WATER

Investigator	Date	Critical Temperature, Deg. Fahr.	Critical Pressure, Lb. per Sq. In.
Nadejdine	1885	676.6	.....
Battelli	1890	687.7	2859
Cailletet and Colardeau	1891	689.0	2994
Strauss	1892	698.0	2873
Traube and Teichner	1904	705.2	....
Holborn and Bauman	1910	706.3	3200

Davis curve are multiplied by $\frac{3200}{1166}$, or 2.745, and the temperatures are divided by 1166, there results a curve expressing the variation of μ with temperature, both expressed in reduced units, according to the best available experimental data.

TRAIN LIGHTING

By H. A. Currie and Benjamin F. Wood

ABSTRACT OF PAPER

This paper reviews the subject of train lighting from the time candles were used to the present day. The methods employed are given in historical order and comprise the candle, oil, gas, and electric lighting systems. The systems appear to occupy a period of 25 years each, beginning with candle lighting in 1825. The early methods of candle and oil lighting are described in brief outline. The gas lighting period is gone into more fully and the systems in general use are described. The electric lighting period is naturally discussed in still greater detail.

The development of the present systems from the time primary and storage batteries were first used is gone into, and the present day straight storage, head-end, and axle equipments are described in detail. Under axle generating systems, the various requirements for successful operation are discussed and the various types of suspension are described. Questions of suitable voltages, lamps, deflectors, and fixtures are taken up and standardization of voltages and batteries are discussed.

Tabulation showing the number of electrically lighted cars, cars to be electrically lighted, types of battery, voltages, number of cells, etc., is included, as is also a train lighting bibliography arranged in chronological order.

TRAIN LIGHTING

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The first railway trains, usually made up of one car, made short trips in the day time only and artificial light was not required; as the trips were extended into the evening the cars were still unlighted. The lighting of stage coaches before the day of railway coaches was obtained by candles brought in by the passengers themselves and placed in sockets along the sides of the coach. It is recorded that the first railway car illumination can be traced to one Thomas Dixon, a driver on a horse train railway in England in 1825, who out of his generosity placed a penny candle on a table in the center of the car for the convenience of his passengers. The early railroad patrons who contemplated traveling by night, and were foresighted, brought their own candles; and later the candles were supplied by the railroad companies in crude sockets, but the passenger had to light them and nurse the flame.

2 A review of the development of railway car lighting shows that it is divided into periods of approximately twenty-five years for each of the illuminants used, beginning with candles in 1825. In 1850 oil lamps were introduced, which gave way to gas in 1875, and this in turn was superseded by electricity in 1900. The development of each of these systems extended over a number of years and the new illuminant did not entirely displace the previous method of lighting. In fact candles are

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sometimes used today for emergency lighting, while oil lamps may be found in many coaches. With the early applications of electric lighting to cars it was usual to retain gas lights for emergency use. Increased reliability of the electric system has now made this precaution unnecessary. Light failures on well-maintained electric service now average in the neighborhood of 1 per 1,000,000 miles.

CANDLE PERIOD 1825 TO 1850.

3 The railroad companies first developed the candle light by placing the candles in proper sockets, putting chimneys around them and deflectors on top of the chimneys. Later the candle flame was kept at a predetermined focus by a spring in the candle socket. The candles used in this country were made from the solid distillates of petroleum formed in molds under pressure, while in Europe wax and tallow dips were chiefly used.

OIL PERIOD 1850 TO 1875

4 The railroad companies recognizing the need of better illumination tried various forms of oil lamps, and in this development the lamps were always the latest improvement as regards safety and reliability. The oils used in this country were distillates of petroleum differing in flame and fire test in the various states and on different roads. The oils used in Europe were vegetable oils, because of the high cost of importing mineral oils and because of the supposed danger from fire. The danger of fire from oil of either class depended, however, more upon the method of containing than in the kindling point, except in the very low flash point distillates of petroleum which were not used directly in railroad work.

5 The European practice for oil lamps was to use rape seed and Colza vegetable oils which are irregular in composition and congeal in cold weather. The difficulties met with in the burning of this oil in Europe led to the development of central draft burners, which were also used in this country to burn heavy oils. The early types of mineral oil burners were merely reservoirs into which fibrous wicks were dipped through suitable holders. Two wicks feeding one flame was the next development, allowing a more copious supply of oil to the flame and a brighter light resulted.

6 The Argand and Belgian burners are representative types of the central draft burner. The Argand burner has a tube and annular wick providing a strong draft of air both to the inside and to the outside of the flame. This results in a high temperature and a bright white light. This burner was the forerunner of several central draft burners used for car, locomotive and station lighting, where a high candle power was desired. A maximum of 60 c.p. has been obtained from one lamp of a size suitable for railway cars by this central draft method. The Belgian lamp represents the highest improvement in delivering a current of air both inside and outside the flame so that it will impinge on the flame at the proper point to produce rapid combustion. Other burners of this type are the Acme, the Student Lamp, and the Westlake lamp.

7 The reservoirs of these lamps were generally of metal and either double glass or specially tough single glass chimneys were used. When the lamps were placed in the center of the ceiling of the car, smoke bells were provided to take off the products of combustion and to protect the flame from drafts. The oil lamps had been generally superseded for first-class service by other illuminants before the development of the incandescent mantle, and therefore, has not been used with the oil lamp in train lighting.

GAS PERIOD 1875 TO 1900

8 About 1870 coal gas was introduced as a head-end system on several railroads as a means of lighting cars. A reservoir in one of the cars, known as the guards van, was filled with gas secured from the city mains and then slightly compressed by water displacement. The reservoir which had a capacity of about 100 cu. ft. was generally square in shape and was made of strong canvas reinforced by wood ribs. Gas was conveyed to the lamps, which burned about 5 cu. ft. each per hour, through iron pipes with rubber hose connections between cars.

9 Nearly ten years later Mr. George Westinghouse devised the "air gas" or carbureted air system. A heavy cylinder, suspended underneath each car, was filled with such material as sawdust, felt, etc. saturated with some light hydrocarbon such as benzine. Compressed air was passed through the tank and, becoming saturated with the hydrocarbon vapor, was conveyed to the lamps where it was burned. The system was never ad-

vanced much beyond the experimental stage, as changes in temperature affected the carburation to a great extent.

10 Carbureted gasolene, made by mixing air and gasolene in suitable proportions was the next system to be used. The best example is probably the Frost Dry Carbureter System. The essentials of this system are that the gasolene be kept from leaking and that the gas be burned as soon after generation as possible without undergoing any change of temperature. The Frost system accomplishes this by locating on the roof of the car directly over each lamp, the carbureter which consists of a chamber filled with wicking soaked in gasolene through which air from the air-brake system is passed at a low pressure, the gasolene vapor being supplied to a burner directly underneath. The products of combustion are passed out through a smoke bell which leads around the carbureter, thus tending to keep the gas at the proper temperature in all weather. The difficulty of maintaining this proper temperature, however, was the chief drawback of the system.

11 The extensive manufacture of calcium carbide by the electrochemical process gave the acetylene system a great impetus. Examples of the acetylene system in extensive use were first, the Adlake system in which about 50 lb. of calcium carbide, placed in a portable steel container installed in a special panel in the car, is arranged so that gas is generated automatically as required by water dropping upon the carbide. In order to obtain this automatic supply, a small tank is placed underneath the car and connected to the steel container, which automatically produces the gas because of the back pressure of the water supply when a certain amount of gas has been generated.

12 The Avery system resembles the Adlake system, except that the generator is placed underneath the car body.

13 The third system used to some extent, is known as the Commercial and in this, acetone, a liquid distilled from wood alcohol and having the property of absorbing acetylene under pressure, is used. The gas is stored in tanks filled with asbestos discs saturated with acetone, and is given off as the pressure in the tank is reduced.

14 Acetylene gas gives a more intense light than any of the other oil or gas systems, but it is explosive and this fact has militated against its extensive use.

15 In 1867 Pintsch, in Berlin, devised the system of gas illumination which bears his name. The distinctive features of this system are, the manufacture of gas from crude petroleum by heat distillation, which gas is not decomposed by compression and subsequent expansion and a regulator which controls the supply of gas to the lamps at a very low pressure for atmospheric burning. Because of its reliability and increased storage capacity, obtained by charging the reservoirs at a high pressure, the Pintsch gas is very extensively used for car lighting. Other systems previously tried, namely, coal, water, and natural gas, did not have these distinctive features and up to that time, were not a success. The substitution of mantle burners for the ordinary fish-tail burners has greatly improved the quality of light, and enabled the Pintsch system to compete on more equal terms with electric lighting.

16. The Pintsch system requires a separate plant with appliances for generating, compressing and storing the gas, also suitable tank cars and pipe lines for conveying the gas to the car reservoirs.

ELECTRIC PERIOD 1900 TO DATE

17 Early in 1881 the London, Brighton and South Coast railway had in operation a straight storage battery system with a battery under each car, the battery being charged during the layover period at terminals.

18 Bichromate primary batteries were tried on trains in France during the year 1885. The scheme was abandoned, however, when the first set of batteries had run down and renewal of the electrodes and acid was necessary.

19 About this time both the Pennsylvania Railroad and the Boston and Albany tried out the straight storage system. The general opinion was that the system was practical but too expensive for general use.

20 In 1888 the Chicago, Milwaukee and St. Paul had in service a train equipped with a head-end system consisting of a boiler, engine, generator, etc., installed in a separate car for supplying light to the train. The present system, developed later, uses steam from the locomotive.

21 The axle driven generator was developed coincidently with electric lighting. The first installation of this kind consisted of a generator connected to a relatively high capacity

battery and hand-operated main switch and pole changer, regulation being effected through the inherent regulation of the batteries taking the excess current at high speeds, thereby holding the voltage nearly constant by armature reaction. Later the brushes were automatically shifted with the speed for voltage regulation. The next step was to allow the belt to slip at speeds in excess of the speed required to deliver current at normal voltage.

22 Various early and intermediate systems were proposed, among which may be mentioned:

a A head-end system deriving power from a fan-driven dynamo on the pilot.

b A track wire system, especially through tunnels, for lighting cars from a trolley.

c A track wire system for charging batteries from an auxiliary trolley while cars were passing through electrified territory.

23 The working out of the early tried system resulted in the more or less general adoption of the following: (*a*) the straight storage system, (*b*) the head-end system, (*c*) the axle generator system.

STRAIGHT STORAGE SYSTEM

24 In this system, each car is provided with a storage battery, which must be charged at terminals during the layover period. A consideration of the requirements for successful operation reveals the following essentials:

The capacity of the battery must be in excess of the demand for current to operate lamps, fans, etc., for the longest run between charging periods.

The power plant, or other outside source of power, must be of sufficient capacity to meet the maximum demand for charging current.

The layover time at terminals must be sufficient to cover all necessary shifting and charging of the batteries at the proper rate.

The yard must have a sufficient number of tracks provided with charging outlets, so arranged that the charging of batteries will not interfere with shifting operations.

25 Two considerations enter into the determination of the

size of the battery; the demand for current and the weight of the battery. The demand for current will vary with the type of car used, the number and size of lamps and other electrical apparatus installed and the time during which this apparatus is used. The battery must be divided into units of a weight that may be readily handled.

26 The batteries in general use in train lighting service have a rated capacity of approximately 300 ampere-hours. This is about the maximum limit of capacity for Plante's type batteries having weight low enough for convenience in handling.

TABLE 1 SHOWING COSTS OF VARIOUS SYSTEMS OF ILLUMINATION PER CAR

	1825–1850 Candles	1850–1875 Oil	1875–1900 Gas			1900 Electric		
			Gasolene	Pintsch	Acetylene	Head-End	Straight Storage	Axle Coach
Passengers carried	4–20	20–50	50–60	60–70	60–70[1]	30–40	[1]40–50	60–70
Candle Power	4–10	20–60	200	300	400	350	250	450
Fixtures and Connections	0 to $3	$10–$60	$500	$400	$500	$700[3]	$600	$1000
[2] Cost of Plant	.....	.....	...	60[5]	$40	25	20	....
[2] Yearly Operating Cost	15–25	40–120	150	150	$200	750	500	200
Yearly Haulage Cost	.....	.....	150	200	$200	400	300	400
Interest, Insurance and Taxes	.....	.....	50	50	$60	100	62	145
[4] Total Yearly Cost	20	60–100	350	400	$500	1250	1350	750
Cost per Year per Seat	1	1.50–2	6	7	$8	31	34	12

[1] At the time of the prevalence of these systems only limited trains were so equipped.

[2] Including all maintenance.

[3] Share per car considering whole train.

[4] Average

[5] Based on capacity for 500 cars.

Basis for above figures, Passengers Carried suppose all seats to be occupied. The Fixtures and Connections are in nearly every case from actual installations. Cost of Plant is the first cost divided by the capacity in number of cars supplied. Yearly Operating Cost includes fuel or power and attendance and maintenance but not all are actual costs, but are filled out by close estimates. Yearly Cost per Seat is simply an arbitrary means of comparing cost per passenger.

Table 2 Methods and Distributions of Car Lighting Systems.

27 The great majority of cars on which this system is used are equipped with a 64 volt lead-lead, or nickel-iron battery with cells connected in series. A few cars are operated at other voltages, viz. 26, 30, 32 and 110. It was the practice of one railroad some years ago to operate at 25 volts, using 12 lead-lead cells in series, with two or more 12 cell sets on a car connected in multiple.

28 Two battery boxes are generally provided and secured

to the under side of the car, one on each side equidistant from the ends of the car, and with the front or door side slightly back of the line of outside finish. The cells are put up in double compartment lead-lined wood tanks provided with handles, rollers, etc., for convenience in handling.

29 The two halves of the battery are connected in series and leads are run to the switchboard in the end of the car. Taps are taken off these leads at the battery terminals and run to charging receptacles, conveniently located on each side of the car.

30 The ampere-hour meter is coming into general favor as an indicator of the state of charge of the battery. As an adjunct a shunt trip circuit breaker is sometimes installed, the connections being such that, when the battery is fully charged, the pointer on the meter closes a circuit which energizes the shunt trip and opens the breaker, thus cutting the battery off charge.

31 The source of power available for charging purposes at terminal yards must be of the proper voltage and of capacity sufficient to meet the maximum demand. The charging voltage provided is usually 50 per cent higher than the normal voltage of the battery. Hand or automatically operated resistance devices are provided for reducing the voltage of the individual charging lines to the proper point.

32 The batteries are charged while on the car under normal conditions. When the layover period is short it is sometimes necessary to exchange a discharged battery for one fully charged.

33 The operating schedule of cars equipped with this system must be worked out to allow sufficient layover at terminals to permit the charging of batteries and shifting of cars. Anything that restricts the shifting operations necessitates either additional yard trackage, additional motive power, or both. As cars produce a revenue only when in service, it is the aim of the transportation department to decrease the layover period to a minimum.

HEAD-END SYSTEM

34 The head-end system consists essentially of a steam-driven generator located in the baggage car or on the locomotive. Proper controlling apparatus is provided and train lines are run from the generator through the entire length of the train, flexible connections being used between cars.

35 So far as can be learned the first head-end system was installed by the Pullman Palace Car Company in January 1887, in some of their composite cars. A three-cylinder Brotherhood engine, direct-connected to an Eickemeyer generator, rated at 80 amperes and 80 volts full load at 1200 r.p.m. was used. These cars were operated in the Atlantic Coast Line Special running between Jersey City, N. J., and St. Augustine, Fla. In June of the same year the Pennsylvania Limited was equipped with the same type of apparatus. In both of these trains the individual cars were equipped with batteries.

36 This system of lighting was afterwards taken up by other eastern railroads but at the present time it is used chiefly on roads operating west of Chicago. Following the Brotherhood engine, the Westinghouse standard engine, the De Laval turbine and the Curtis turbine entered the field in turn.

37 The Pennsylvania Railroad conducted a series of experiments with the "Gould Booster" head-end system, which consisted of a compound-wound turbine-driven generator mounted on the locomotive, with a motor-generator booster and automatic switches mounted on the tender. Four train line wires were run underneath the cars and were joined together by connectors that uncoupled automatically when the cars were parted. A battery and transfer switch were provided on each car. In this system, unlike any other in use at that time, the entire control was automatic after the generator was started.

38 The head-end system of today comprises the following apparatus:

A generator, usually steam turbine-driven, placed in the baggage car or on the locomotive, and furnished with steam from the locomotive.

The necessary indicating, regulating, and controlling apparatus placed near the generator and in an accessible position.

Train line wires of the proper size on each car and running the entire length of the train, flexible connections being made between cars, in the vestibule.

Batteries, consisting of a suitable number of cells connected in series and placed in battery boxes attached to the under side of the cars.

Lamp regulators are sometimes installed in the cars to compensate for the line drop and to maintain constant voltage at the lamps.

39 The successful operation of this system requires that a sufficient amount of steam at the proper pressure be provided when lighting is necessary. As it is the object of the transportation department to get trains to their destination on time, lack of steam is felt first by the lighting system, the pressure being reduced or steam cut off entirely so that the schedule may be maintained.

40 When the train is broken-up en route, it is obvious that each section must either be equipped with a battery to insure light until the train is again made-up, or provided with some auxiliary light.

41 A member of the train crew must be capable of operating the generating apparatus and of making running repairs and adjustments en route.

42 Head-end systems are generally operated at 64 or 110 volts, although in late years the introduction of tungsten lamps has gone a long way to eliminate the need of the high voltage equipments and comparatively few railroads are now using 110 volts.

43 It is apparent that the use of the head-end system must be restricted to a few trains having assigned runs or that it must be extended to cover all the cars operated by the railroad in electrically-lighted trains.

AXLE GENERATOR SYSTEM

44 The axle generator systems used in this country comprise the following principal parts:

a An axle-driven generator mounted on the car truck. (Abroad where rigid trucks are used the axle generator is frequently secured to the under side of the car body.)

b A suspension by which the axle generator is supported from the truck frame.

c A drive, connecting the armature shaft to the axle.

d A regulator for controlling the voltage and output of the generator at all train speeds.

e An automatic switch designed to open on reverse current for the purpose of preventing discharge of the battery through the generator.

f A regulator for controlling the voltage impressed on the lamp circuits.

g A battery of a suitable number of cells to supply current when generator current is not available.

45 For the successful operation of the system, the following requirements must be met:

The polarity of the generator terminals must remain unchanged with a movement of the car in either direction.

At all train speeds, from the cutting-in speed of the generator to the maximum, the generator output and voltage must be maintained within the desired working limits.

The generator must be automatically connected and disconnected from the battery circuit as the train speed rises above or falls below the critical speed.

The lights may be burned at any time and the transfer of this load from the battery to the generator and vice-versa must result in no appreciable change in the candle power of the lamps.

The voltage impressed on the lamp circuit must be maintained within such limits as will give satisfactory illumination and reasonable life of lamps.

46 The early axle generators were practically all of the constant current type. The generator maintained a constant current, only that portion going to the battery that was not required by the lights. The generator output could be varied by hand adjustment, and it was necessary to adjust the generator output so that there would be an approximate balance between the battery input and battery output, account being taken of the battery ampere-hour efficiency. This requires consideration of the following factors: (*a*) the ampere capacity of the generator, (*b*) the ampere-hour demand during the trip. The demand varies with the number and size of lamps installed, the run in which the car is operated, the number and duration of stops, and the proportion of total running time of the train below cutting-in speed. A change of the car from local to through service, or vice-versa, required a complete readjustment of the regulation. A failure to so readjust would quickly result in battery deterioration, the plates becoming sulphated with a low generator output, while a corresponding high output would

boil away the electrolyte. In a variation of this method the battery was charged at a definite rate, generally the normal charging rate, while the generator output varied with the lamp load. In more recent systems constant current is maintained until the generator voltage, increasing as the counter e.m.f. of the battery, reached a definite value, after which one of two results would obtain, depending upon the design of the control apparatus. In one the generator voltage was held approximately constant producing what was known as the taper charge or a gradual decrease in the rate of charge. In the other, the generator voltage was automatically reduced to the " floating " e.m.f. of the battery and maintained approximately constant. This was known as " stop charge " regulation.

47 Both methods originally depended upon the operation of a voltage coil actuating a switch, which in turn changed the field current by means of resistance. Premature closing of the battery stop charge switch resulted in undercharging and consequent sulphating, while delayed closing caused overcharging and the boiling away of the electrolyte.

48 These devices are being superseded by a system using a voltage coil in the regulator instead of the voltage switches previously mentioned. Here the current output is maintained constant to the full generator capacity regardless of the current demand, and the battery must supply all current in excess of the capacity of the generator. As the battery becomes charged the generator voltage gradually increases and at a predetermined voltage the voltage regulating coil takes the control of the generator from the current regulating coil and when the battery becomes fully charged the current decreases until the battery is " floating on the line." As the voltage on the battery on charge is approximately 30 per cent higher than on discharge, it is necessary to provide some means of lamp regulation in order to keep a constant voltage on the lamps. In the early axle generating systems this was accomplished by introducing a fixed metallic resistance into the lamp circuit at the instant the automatic switch closed transferring lamp load from battery to generator. This method, however, was not altogether reliable as the generator voltage varied with the condition of the battery and the number of lamps burning. The variation of the voltage due to these conditions soon led to the development of a variable metallic resist-

ance in place of the "fixed" resistance. In this method of regulation the amount of resistance in the circuit was varied by means of the operation of a small auxiliary motor operated by a voltage relay or other means.

49 A later type of lamp regulator employed, as a means of regulating resistance, a series of carbon blocks, the resistance being varied by varying the pressure on these blocks, the variation of pressure being determined by a pilot voltage coil connected across the lamp mains.

50 In this country it is the general practice to support the axle generator from the truck frame. When first applied, the generator was placed between the axle and the truck-end sill, this arrangement being known as "inside suspension." The generator was not easily accessible for inspection and repairs, and at the present time it is placed outside of the truck frame, this arrangement being known as "outside suspension." There are four general methods of carrying the generator from the suspension framing, viz. bottom pivoted, top pivoted, parallel link and sliding. The bottom pivoted was first used but at the present time the parallel link suspension is in more general use.

51 The drive usually used employed a rubber-filled canvas belt running on pulleys on the axle and the armature shaft. The axle pulley as first used was cast iron mounted directly on the car axle, the bore of the pulley conforming to the taper of the axle, but on account of inequalities in the axle which was hammered or rough-turned, it was wrapped with tarred paper. The axle pulley at present in use is of pressed steel, mounted on a steel bushing, the bushing being secured independently to a turned seat on the axle, and the pulley mounted thereon. Belt tension is provided by means of springs which also afford relief to the belt due to the movement of the car axle with respect to the truck frame. One spring is generally used when the generator has top, bottom or sliding suspension and two springs with the parallel link suspension. Chains of the silent type have also been tried and have the advantage of positive action and decrease in bearing pressure, but the wear of the links both on the face and the pivot sprockets has been excessive. Belts of V section have been tried and would seem to have the same advantages as the chains, but it is found that in winter the bottom of the V groove in the sheaves packs with

ice and snow, and driving power is lost. Neither the chain nor V belt requires tension device.

52 A form of shaft drive, from a bevel gear on the car axle, through an extensible shaft with universal couplings to a generator carried from the car body, is being tried. A gear drive, with the generator mounted on the car axle after the manner of the street car motor mounting has also been prepared and will soon be tried. The latter will no doubt require a track pit for the inspection and repair of the generator.

53 Plain bearings with ring oilers were used almost exclusively until five years ago. With this method of lubrication, it was necessary to carry the oil level so high that it frequently entered the generator frame and damaged the armature and field coils. To overcome this trouble, a form of wick oiler was tried which, however, proved unsatisfactory. The next improvement was a combination ring and chain oiler, which is now in general use on one type of machine. Waste-packed bearings have also been extensively used and have given no trouble on account of oil entering the generator frame. Considerable trouble, due to hot bearings has been experienced. Ball bearings for axle generators were introduced in England about 1907 and tried in this country in the early part of 1911. Although the use of ball bearings to date has been limited, the indications are that this bearing will become very popular on future machines. On account of the widely varying temperatures between summer and winter conditions that obtain in the operation of axle generators, it was necessary to develop special oils that would remain fluid at low temperatures. Those now used have a freezing point of 10 deg. fahr. For ball bearing lubrication grease should be free from acid or alkali; should not oxidize or evaporate; should not gum or lose its body.

LAMPS AND VOLTAGE

54 The early train lighting lamps were of the ordinary multiple burning type regularly manufactured, and as the demand increased manufacturers took up the development of lamps especially adapted to train lighting. One of the requisites of these lamps is that the smallest size bulb consistent with reasonable life of lamp be used.

55 Among the early lamps was a foreign-made carbon-filament lamp operating at 4 watts per c. p. Some time later, a

carbon lamp operating at 3.5 watts per c. p. was developed by American manufacturers.

56 It was found that the future of electric car lighting depended to a large extent upon whether or not lamps of still higher efficiencies could be manufactured in large quantities. About this time the tungsten lamp was introduced in regular multiple burning service and investigations were immediately started with a view to adapting it to car lighting. The use of tungsten lamps, however, was looked upon with some doubt on account of the extremely fragile nature of the filament, especially in the smaller sizes. Eventually a 25-watt lamp was developed. This did not improve conditions appreciably, since many of the carbon-filament lamps were approximately of the same wattage. Further investigations resulted in the development of a 15-watt lamp which improved conditions sufficiently to warrant its use in large quantities and made it possible to light a car at a reasonable current demand. With the introduction of tungsten lamps the standard voltage of axle generators has been changed from 60 to 30 volts.

57 Coincident with the introduction of tungsten lamps into train lighting service there was introduced the so-called "hot filament" system. The basis for this system was the belief that a tungsten filament of the early type when heated to about 400 deg. fahr., was less fragile than when cold, so that by maintaining the filaments at this temperature the life of lamps could be materially increased. A circuit switching arrangement was provided whereby the lamps were operated across 30 cells of battery when light was desired and across the two remaining cells of the battery at other times, this being sufficient to keep the filaments at a dull red. Later, the introduction of the drawn wire filament rendered this system unnecessary, and it has been abandoned.

58 Metalized-filament lamps with small opal bulbs, operating at about 2½ watts per c. p. were developed for berth lighting. These lamps gave satisfaction at first, principally because berth lights had never before been furnished. As the public became educated to their use, the demand for more light in berths became pronounced, so that it has been found necessary to use the 15-watt tungsten lamp as a berth lamp, and the use of metalized filament berth lamps is decreasing very rapidly.

59 Tungsten lamps for train lighting purposes are now furnished in 10, 15, 20, 25 and 50-watt sizes, although the bulk of

TABLE 2 METHODS AND DISTRIBUTION OF CAR-LIGHTING SYSTEMS

Railroads	Cars Lighted by Electricity	Cars Lighted by Other Means	Straight Storage		Cars with Turbine	Head-End System		Axle Generator System		Owned and Operated by Railroad Company	Owned and Operated by Pullman Company	Cars Contracted for	Number Cells Lead Battery	Number Cells Nickel, Iron. Alkaline Battery
			No.	Volts		No.	Volts	No.	Volts					
A., T. & S. F. .	682	1120	0	0	0	0	0	682	30	632	50	50	11552	25
B. & A.	7	434	0	0	0	0	0	0	0	7	0	0	708	0
B. & O.	246	1105	28	60	11	67	64	19	60	143	103	0	3028	100
	. .	. .	.	.	. .	. .	. .	29	30	. .	. .	. .	. .	. .
Can. Pac.	165	2273	0	0	0	0	0	128	24	128	0	37	3072	220
C., St. P., M. & O.	58	265	0	0	4	0	64	2	60	2	0	0	192	0
C. of Ga.	6	258	0	0	0	0	0	6	30	0	0	0	80	50
C. & A..	103	100	56	32/64	0	0	0	34	32 64	103	0	0	0	0
C. & E. I.. . . .	93	107	2	32	0	0	0	77	32	79	14	0	1264	0
C., B. & Q.. . .	710	591	0	0	52 cr	52	60	2	30	0	0	0	5508	0
	. .	. .	. .	.	16 en	16	64		.	. .	. .	. .	. .	. .
C.,M. & St. P.	990	368	30	64	58	58	64	9	64	930	. .	60–64	3872	0
	. .	. .	. .	. .	.	.	.	2	32	. .	. .	. .	. .	. .
C. G. W.	70	102	0	0	0	0	0	70	30	70	0	0	736	216
C. & N. W.. . .	672	1000	0	0	23	200	64	17	60	572	100	0	2200	25
	. .	. .	. .	. .	. .	. .	.	35	30	. .	. .	. .	. .	. .
C., R. I. & P. .	344	805	0	0	0	0	0	301	30	0	0	36–30	5024	125
	.	. .	. .	. .		. .	.	6	60	. .	. .	1–60	. .	.
C., C., C. & St. L..	46	552	2	0	0	0	0	44	32 64	103	0	0	0	0
D., L. & W. . .	44	738	0	0	0	0	0	44	30	0	30	0	704	0
	. .	. .	. .	. .	. .	. .	. .	1	60	. .	. .	. .	. .	. .
D. & R. G. . . .	30	348	0	0	0	0	0	29	32	0	0	0	512	0
E. P. & S.W. .	17	46	0	0	0	0	0	17	30	0	0	0	272	0
Erie.	156	1788	74	30	0	0	0	72	30	146	0	10–30	2448	0
G. N..	551	402	11	110	45	550	110	1	30	953	0	0	3040	0
G. R. & I.. . . .	33	86	28	60	0	0	0	1	60	33	0	0	912	0
	. .	. .	.	. .	.	.	. .	4	30	. .	. .	. .	. .	. .
G. T..	106	0	0	0	0	0	0	15	24	31	75	0	840	0
	.	.	.	. .		. .		15	30	. .	. .	.	. .	. .
	. .	.	.	. .	.	. .	.	1	60	. .	. .	. .	. .	. .
F. W. & D. C.	22	31	0	0	0	0	0	22	32	0	0	0	336	25
Ill. Cen.	330	770	10	30	0	0	0	320	30	240	90	0	2240	3050
	. .	. .		. .	.	. .	. .	3	60	. .	. .	. .	. .	. .
K. C. So..	21	57	0	0	0	0	0	18	30	0	0	0	384	0
L. V.	219	340	0	0	0	0	0	196	32	0	0	23–30	3480	24
L. I..	113	404	3	64	0	0	0	109	32	0	0	0	3680	125
L. S. & M. S. .	139	634	0	0	0	0	0	72	30	0	0	0	0	0
	. .	. .	1	64	.	. .	.	47	60	. .	. .	. .	3312	. .
L. & N..	67	558	1	32	0	0	0	59	32	0	0	532	1120	75
M. P.	208	739	1	32	0	0	0	109	32	0	178	0	1824	0
M. & O.	6	119	0	0	0	0	0	6	.	6	0	0	0	0

TABLE 2—CONTINUED

Railroads	Cars Lighted by Electricity	Cars Lighted by Other Means	Straight Storage		Cars with Turbine	Head-End System		Axle Generator System		Owned and Operated by Railroad Company	Owned and Operated by Pullman Company	Cars Contracted for	Number Cells Lead Battery	Number Cells Nickel, Iron, Alkaline Battery
			No.	Volts		No.	Volts	No.	Volts					
M. & St. L.	19	76	0	0	0	0	0	19	32	17	2	0	304	0
M. C.	60	438	0	0	0	0	0	18	60	0	0	12–30	1248	0
	..	..	..	..	..	..	..	30	30	..	..	..	..	..
M., St. P. & S. St. M.	65	328	0	0	0	0	0	65	32	0	20	0	1072	0
N.Y.C.&H.R.	376	528	0	0	0	0	0	376	32–64	376	0	48	6624	54
N.Y.C.&St.L.	2	.	0	0	0	0	0	2	60	0	0	0	64	0
N.Y., N. H. & H.	330	2103	0	0	0	3	110	113	30	330	0	36–60	7280	270
	..	..	..	..	..	..	..	178	60	..	..	.	..	..
N. P.	667	492	0	0	53	658	64	9	64	0	0	0	28621	0
N. R. of Mex.	36	..	0	0	0	0	0	31	32	9	22	5	592	0
N. & W.	77	382	0	0	0	0	0	13	30	13	30	64	0	1600
O. S. L.	84	198	1	32	6	82	64	1	32	282	82	23	480	0
O. R. & N.	56	55	0	0	7	55	64	1	60	131	0	0	436	0
Pullman	2400	1864	6	0	0	0	0	2400	30	0	0	0	38400	0
P. & L. E.	4	134	1	60	0	0	0	2	30	0	0	0	96	0
	..	..	1	30	..	..	..	..	..	..	..	..	..	..
P. M.	102	259	0	0	0	0	0	102	32	102	0	0	1632	0
St. L. & S. F.	246	388	0	0	0	0	0	236	32	0	76	10	3820	0
St. L. & S. W.	15	208	0	0	0	0	0	4	60	0	11	0	304	0
	..	.	..	..	..	..	..	11	30	..	..	..	..	..
So.	258	..	0	0	0	0	0	228	30	0	0	30	4128	0
S. P.	145	1400	2	0	0	71	64	72	32/64	145	0	0	2200	0
S. P., L. A. & S. L.	76	97	1	0	0	55	64	20	32/60	24	0	0	608	0
T. & N. O.	76	533	0	0	0	0	0	16	64	16	47	0	512	0
T. & B. V.	16	12	0	0	0	0	0	16	32	0	0	0	176	125
U. P.	221	346	0	0	32eng	202	63	13	64	221	0	44	2020	64
	..	..	..	..	.	..	..	6	32	..	..	..		..
W. & L. E.	4	72	3	0	0	0	0	1	..	4	0	0	0	0
W. P.	86		0	0	0	0	0	85	32	0	0	0	0	0
	..	..	..	..	.	..	..	1	64	87	..	..	1392	..
Penna. East	1092	2310	845	60	0	0	0	19	60	1226	0	489	53632	2550
	..	..	..	..	.	..	.	228	30	..	..	..	..	..
Penna. West.	581	717	526	60	0	0	0	5	30	581	0	54	22592	50
	..	..	..	..	.	..	..	50	60	..	..	..	..	..
Vandalia	53	116	42	60	0	0	0	11	60	53	0	0	2128	0
Wabash	..	.	..	..	.	..	..	..	..	..	..	..	..	..
Total, June 30, 1912.	13786	29275	1680	..	307	2069	..	7060	..	7847	1330	1849	242932	8817
Total, June 30, 1911.	11017	33634	1372	..	192	3185	..	5900	..	..	..	..	202744	..

demand is concentrated upon 15 and 50-watt lamps. Spherical bulbs are used almost exclusively, 3¾ in. in diameter for the 50-watt lamp and 2 5/16 in. in diameter for the smaller sizes.

60 The voltage of the lamp is necessarily dependent upon the voltage of the generating system. An investigation of the records of the principal railroads shows the use of the following voltages at the present time: 24, 26, 30, 32, 60, 64 and 110. The bulk of the demand for train lighting lamps is concentrated on two voltage groups, the 30 volt, which includes lamps between 25 and 34, inclusive, and the 60 volt, which includes lamps of from 50 to 65 volts, inclusive.

61 From an engineering standpoint, it is highly desirable that as many of the voltages, wattages and sizes of bulb as is possible be eliminated. From a manufacturing standpoint, it is desirable that some variation be allowed in the voltages, as a large number of high-voltage and low-voltage lamps are accumulated in the manufacture of lamps of a fixed voltage. This brings up the question of the inspection of lamps before purchase.

62 On account of the method of manufacture of train lighting lamps, manufacturers have found it most convenient to inspect the lamps for initial variation by holding the lamps at a fixed candle power, allowing the voltage and current to vary. From the railroad standpoint, this method of inspection seems to be wrong, as the voltage of the circuit is maintained at a very closely fixed value in actual service. If the manufacturers could be persuaded to do so, it would be much more desirable to have lamps inspected by holding them at a predetermined voltage, allowing the variations to take place in the wattage and candle power.

63 According to the present method of inspection, a variation of 5 per cent above and below in voltage and 8 per cent above in watts is allowed. If the demand is concentrated too greatly upon one type of lamp, it will probably be necessary to increase these limits. On the other hand, if the railroads among themselves can standardize their voltages close enough for each voltage class to permit the use of any of the lamps on any railroad, the demand for any one voltage lamp will probably not be great enough to make the increasing of the limits of inspection above mentioned necessary.

64 Until recently little attention has been given to the de-

velopment of reflectors adapted particularly to railroad service. There are several very efficient reflectors now on the market which in some cases have increased the intensity of the light on the reading plane in a passenger car as much as 65 per cent without changing the current consumption or the candle power of the lamps. To secure the best results, attention must be given to the proper location of the filament relative to the reflector.

65 The question of sockets also plays a very important part in car lighting. The socket must be sufficiently rugged in its construction to withstand the jar and vibration encountered in the handling of passenger equipment cars. It must also be so constructed that when the lamp is screwed home there will be sufficient spring in the inner shell and contact to lock the lamp in position, holding it so tight that it will not become unscrewed by the jar and vibration.

STANDARDIZATION

66 The Association of Railway Electrical Engineers has made recommendations as to the standardization of many of the details pertaining to electric car lighting and a number of the railroads of the country have already indicated their intention of following these recommendations by changing their equipment to conform to the recommended practice.

67 The standard voltages recommended by the Association of Railway Electrical Engineers are:

60 volts (nominal) for straight storage and head-end systems

30 volts (nominal) for axle generator systems

68 The lead battery has been fairly well standardized and the construction recommended includes a two-compartment lead-lined tank with rubber jars. The principal variations from the standard in the lead batteries are that some roads are now using lead covers in place of the rubber covers, this change being made to lessen the danger to battery repairmen on account of gas explosions, and the difference in the method of making the connections to the battery posts.

69 The differences in batteries are not of such a character as to preclude the interchange of batteries on different roads.

70 The nickel-iron battery is manufactured only by one company and therefore the battery is more easily obtained to standard construction and dimensions.

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EFFICIENT PRODUCTION OF CYLINDRICAL WORK

By C. H. Norton

ABSTRACT OF PAPER

Early grinding machines were designed for the purpose of producing a higher degree of refinement than was possible with the lathe, both being used as tools of refinement. Later developments show that the highest efficiency is secured in the great majority of cases by using the lathe solely as a roughing tool, transferring the entire responsibility for refinement to the grinding machine.

The process of roughing is not to be considered in the usual sense of turning to a few thousandths of an inch over the finished size, since this involves an element of refinement and loss of time. The workman at the lathe should use the coarsest feeds possible without regard to finish, calipering the work at the beginning of a cut only, where the tool should be fed by hand for a short distance for this purpose. While a piece roughed out in this manner may require a longer time for grinding than if roughed out more carefully with a certain degree of refinement, the combined time for lathe and grinding machine will be less than if part of the refinement was done by the lathe.

Several examples are quoted by the author of work which has been ground in accordance with the principles outlined. It is held that lathe departments and grinding departments should be conducted under one head, instead of separately as is usually the case, to avoid the tendency of the lathe department to consider its work as a finished product, and of the grinding department to insist on careful turning in order to make a better showing of time required for grinding.

EFFICIENT PRODUCTION OF CYLINDRICAL WORK

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Non-Member

Turning is one of the oldest of the mechanic arts, and the lathe is one of the oldest metal working machines; but the lathe has been a very inefficient tool until the present time. We now have lathes so designed that they can be made efficient. I believe, however, that we are not as a rule using the modern high power lathes as we should, and are losing what they were designed to save, viz., *time;* that while we use them as roughing machines we also use them as refining machines.

2 Most cylindrical work must finally have size within small limits and be truly cylindrical within still smaller limits, which led mechanics in the past to study the art of refined turning. When this art had reached a high degree of refinement, men discovered that it did not satisfy them and cylindrical grinding was introduced to give more refinement than could be obtained with the lathe. The natural conclusion at that time was that the grinding machine should take up the work of refinement after the limit of refinement had been reached with the lathe and the early grinding machines were, therefore, designed with this thought in view.

3 Later, however, it was shown that ground cylindrical work could be produced at a cost no greater than the turning alone had cost, simply by using the lathe to remove a large proportion of the metal necessary to be removed and not at all as a means of refinement; transferring the entire responsibility for refinement to the grinding machine.

4 While some understand this and are producing cylindrical work efficiently, I believe the great majority are still under the

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spell of tradition, and are turning what they call "good work:" work that shows care and skill on the part of the operator and accuracy in the lathe. Such care and skill with turned work is even more senseless today than the old time practice of shaping acorns on all screw heads and putting cast iron eagles on the tops of machine tools, because in case of the former the grinding machine removes all trace of the lathe's accuracy and the operator's skill in a moment of time, while the latter remained for years to gratify the taste of those who had an eye for such artistic embellishment.

5 The developments of the last few years have brought about the facts that, except in rare cases, efficiency in the production of cylindrical work means, (*a*) the use of the lathe as a roughing tool only, and (*b*) the modern grinding machine for refinement.

6 Most lathe operators and most foremen seem to understand roughing to be simply the turning of work a few thousandths over the finish size, when in reality they are not roughing at all, but simply turning to a certain degree of refinement with the notion that by so doing they are (*a*) doing a creditable job, and (*b*) that they are helping the grinding machine. It is difficult to secure roughed work from lathe operators, i.e., work that is not in any sense refined.

7 Tradition impels nearly all to consume much more time than would be necessary if the work were merely roughed, roughing being confused with a certain degree of refinement. Roughing is not refinement of any degree, and refinement does not necessarily mean perfection. There are many degrees of refinement, but never degrees of accuracy or perfection. Accuracy and perfection are final and fixed, they have no limits.

8 Those who would produce cylindrical work efficiently must recognize the fact that different cases require different degrees of refinement, and whether the work requires a very low degree of refinement or a degree closely approaching accuracy, the lathe work, to be efficient, should be the same, viz. as *rough* and as *cheap* as it is possible to make it.

9 The lathe today should be a roughing tool only, and the grinding machine a refining tool only, not a perfecting tool. Some grinding machines may produce greater refinement than others, but none can produce literally exact and perfect cylinders. While it is true many mechanics look upon a high degree of

refinement as accuracy and speak of it as such, it is easy to prove that it is not accuracy, but simply a high degree of refinement. When all recognize these facts there will be greater efficiency in the production of cylindrical work.

10 Because these facts about roughing and refining are not well understood and men do not combine the lathe and grinding machine in a well defined and efficient manner, the machine industry and railroads are losing large sums each year and I will try to show where some of the loss occurs.

11 We are losing because we turn closer than *about* 1/32 in. above the finish size. I use the word *about* because we lose by turning carefully. To require lathe work turned to thousandths today is like burning money for the fun of it. We are losing by allowing workmen to use any but the coarsest feeds possible in each case, even to the use of the screw cutting gears to obtain them.

12 Feeds as coarse as four to the inch should be used in some cases and six, eight and ten should be quite common. When work is too frail to allow such feeds with one cut, then another, or even three cuts should be made at faster cutting speed; for, while it is true that very coarse and imperfect turning will require longer to grind than close, careful turning, the combination of coarse, cheap turning with grinding will produce cylindrical work more efficiently. The modern grinding machine will remove metal most efficiently when that metal is in the form of coarse screw threads.

13 High ridges do not increase the cost of production. We lose money when workmen are allowed to caliper cylindrical work on the tops of the ridges, as nearly all do. This accounts for the misunderstanding about coarse turning and the allowance for grinding. Calipering on the tops of the ridges makes it necessary to turn with relatively fine feed to enable clean grinding. To avoid this some workmen use a broad nose tool with the coarse feed which necessitates slower cutting speed because more metal is removed than with a pointed or grooved cutting tool. Ridges left by a more pointed tool do not increase the cost of producing that work, but decrease it.

14 It is so simple to feed by hand a slight distance at the end of the work, where the calipering can be done correctly, however coarse may be the power feed later, and however high

the ridges. Money is lost by allowing workmen to measure roughed work elsewhere than at the end; hours are wasted by operators calipering at several points and then because of spring or tool wear, resetting and turning that portion again to secure straight work. They forget that the modern grinding machine was designed to do all of the straightening and all of the sizing, regardless of what the errors of roughing may be. They forget, or have never known, that the art of producing cylindrical work has progressed beyond that stage where it was necessary for the lathe to do its best before the grinding machine assumed the work of refinement.

15 The modern grinding machine is literally a correcting machine. The roughing can literally be rough, and roughness does not mean an approximate refinement. It is easy to figure the saving in time of turning a piece of work 6 in. in diameter by 6 ft. long when the last cut before grinding is made with a feed of six per inch, instead of 32 per inch which is very common. When it is considered that the grinding machine will grind this six per inch work to the finish size complete in less time than is required to file 32 per inch work, we see the great possibilities for saving cost with the lathe, if combined with a modern grinding machine.

16 In some cases money is lost by roughing at all in the lathe. Please note that I say *in some cases*. Efficient production of cylindrical work is usually accomplished by roughing first in the lathe; but there are cases when the difference in favor of grinding without first roughing in the lathe is very great.

17 The most important study for those who would secure efficient production of cylindrical work is the roughing of that work. It is here that the greatest possibilities for saving lie. If all would make a careful study of the roughing preparatory to grinding instead of trying to improve upon the methods of grinding advocated by grinding machine makers, there would result a more efficient production of cylindrical work and a clearer view of the real reasons why the grinding machine maker advocates certain methods, and why the modern heavy grinding machine was introduced.

18 At a works where large numbers of cylindrical pieces are manufactured 1⅛ in. in diameter and about 10 to 11 in. long, 5 minutes was required to turn each, removing about 1/16 in. from

the diameter using a high-speed steel tool and revolving as rapidly as the tool would stand. The plan was to turn close to the finish diameter and care was taken to secure straight, smooth and round work to save time when grinding, because they considered the grinding expensive, and that this expense must of course be added to the cost of turning. The grinding in this case was 1 minute. The total time for producing these pieces was 6 minutes.

19 A change was made in the shape of the tool point and the size limit for turning increased. The traverse feed was increased, the cutting speed remained unchanged and the work was turned in 1 minute each, while the grinding time was doubled, viz. 2 minutes; the saving was 3 minutes, or one-half of the original time.

20 Some idea of what is lost by allowing lathe work to be turned straight, smooth and close to size before grinding may be obtained from the following illustration of actual work on some forgings about 4 ft. 6 in. long, turned portion to finish 2 in. plus or minus 0.0005 in. in diameter, and 3 ft. long. The lathe operator turned these in the same manner that the majority of operators are now turning such work, viz. as such work was turned before grinding machines were introduced, except that 0.010 in. was left on the diameter for grinding. The turning required two cuts, as there was more than ⅛ in. to remove and the work was somewhat frail as well as irregular. The first cut was considered by the workman a very coarse heavy cut; the second was like the last cut in the majority of shops, viz. it gave what the lathe men and most foremen call " a good job." When ready for grinding the time consumed by turning was a total of 25½ minutes. This appears to be too slow, but the forging was too slim to allow little, if any more, with one rough cut, and the lathe was an old-time weak power frail machine. The grinding time on this was 3 minutes, making a total of 28½ minutes.

21 When tradition was ignored and the work was made ready for grinding in the proper way, the following saving was accomplished: Two roughing cuts were taken, because (*a*) the lathe was not powerful, and (*b*) the work was frail. The feed was ten per inch, cutting deep grooves; the time complete ready for grinding was 9 minutes. The work was not straight, and was what lathe men would style " a very poor job." The grind-

ing time to the exact limits was 9 minutes, or three times longer than with the more careful turning; a total of 18 minutes, a saving of 10½ minutes on each forging.

22 An attempt to rough this work with one cut instead of two resulted in a loss of 2 minutes. A modern lathe having more power with the direct belt would have carried the same feed and depth of cut at higher cutting speed with a still further reduction of time. This shows what may be accomplished with weak low power lathes.

23 To install high power lathes and continue to turn just as smoothly and accurately as of old, simply allowing a few thousandths for grinding, would seem the height of wastefulness. Whether high power lathes or old low power lathes are used mechanical industries are losing an enormous sum each year because of the lack of understanding of the real problem affecting the efficient production of cylindrical work, which is the proper combination in each individual case of rough turning and grinding.

24 Some idea of what we are losing by not wearing our "thinking caps," is shown by the following: Some plain shafts, 1 5/16 in. in diameter, 62 in. long were to be made to ordinary limits of size and finish. Tests were made to determine whether it was better first to turn these or to grind direct from the rough bars. The turning required 6 minutes ready for finish grinding, while to grind off the same amount as was turned off required 9 minutes. A number of mechanics pronounced it cheaper to turn the shafts first. "Of course." But in this case after turning in 6 minutes, each shaft required straightening before grinding, which consumed 10 minutes, totaling 16 minutes. When the roughing was done by grinding instead of turning no straightening was necessary, and the roughing cut was removed in 9 minutes.

25 In this case, therefore, the turning was actually lost. There may be similar cases where the shafts will require some little straightening even if roughed by grinding, so that each case should be investigated instead of making a rule that all must or must not be turned first. Usually, however, no straightening is necessary when the roughing is done by grinding.

26 Money is being lost because the majority of designers have not kept pace with the development along these lines. A

well-known runabout motor car has a crankshaft, which if made about 1 in. longer over-all could be produced for 50 cents less on each crank. When it is considered that about 30,000 of these cranks have been made, representing a possible saving of $15,000, we see the importance of considering the combination of lathe and grinding work.

27 Fig. 1 shows a design of crankshaft that is expensive to machine, since it requires carefully finished lathe work. It will be seen that this shaft has a flange that must be finished complete with the lathe. Aside from the flange also the design necessitates lathe finishing of the majority of the work. Grinding is a small part of the whole.

28 Fig. 2 shows a design that requires no lathe work whatever, there being clearance for the sides of the grinding wheel at all points. The illustration shows the six operations necessary to complete the shaft after cutting off the ends and centering.

29 These shafts are finished to the usual limits directly from the drop forging by grinding. The net labor cost for cutting off ends, centering, and machining complete with one keyway and the thread ready for the automobile, is 55 cents. The cost for grinding wheels is 2½ cents each; cost for diamonds to true and shape the wheel, is 2 cents each.

30 Another feature affecting the cost of production is the matter of ordinary shoulders. This is overlooked by many designers and practically all draftsmen. It is easy to draw two sharp lines that cross each other and form a sharp corner and the fact that it costs less to provide room for the shoulder fillet on the other member than to make a sharp corner in the cylindrical member is lost sight of. This no doubt is the result of the experience of the past when there were no powerful grinding machines to locate and form such shoulders cheaper than the lathe. Shoulders to be made with the grinding wheel require a slight fillet.

31 When numbers of duplicate pieces are to be produced and a small fillet is allowed, not only can the cylindrical portion be roughed with the lathe and not at all refined, but the shoulders can also be roughed, because the grinding machine, when required, is provided with a locating bar. By the use of this bar, the exact location of all shoulders can be secured by grinding and without measuring. At the same time the cylindrical

portion can be ground with the same grinding wheel. The roughing in the lathe can be done with the same tool that roughs the cylindrical portion because the lathe in this case is not required to give to the shoulder any particular shape. When it is found best to *locate* and *finish* shoulders with the lathe because there is no locating bar for the grinding machine, it should not be necessary to neck in at the shoulders for grinding. This is an old and out-of-date notion, for, with a shoulder cut sharp by the lathe tool, the grinding does not materially change the corner.

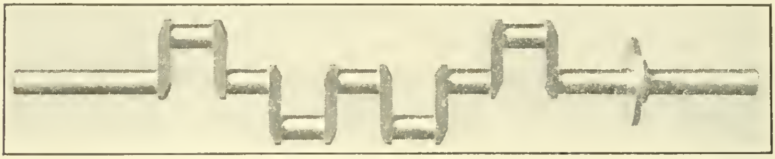

Fig. 1 Example of Expensive Design

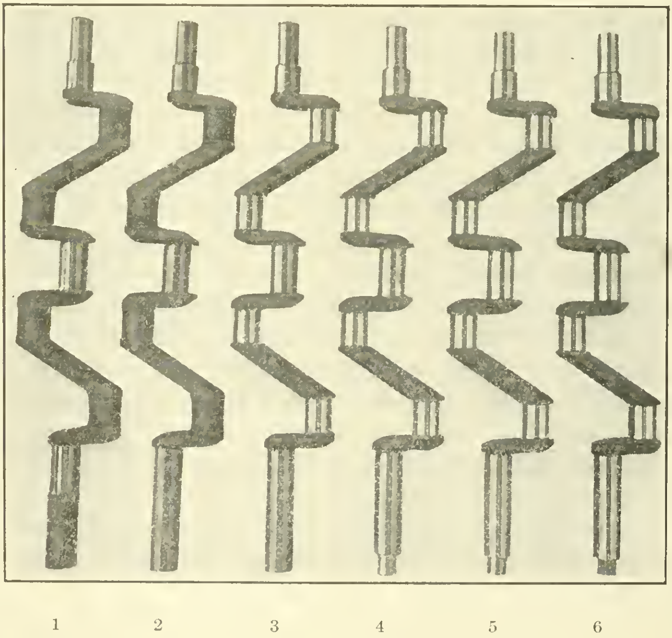

Fig. 2 Examples of Inexpensive Design

32 A more efficient method when no locating bar is at hand

is to rough the work in the lathe, leaving the shoulders about 1/32 in. long and whatever angle the roughing turning tool may form. Next grind the cylindrical portion and at the same time cut out the angle at the shoulder with the grinding wheel. The

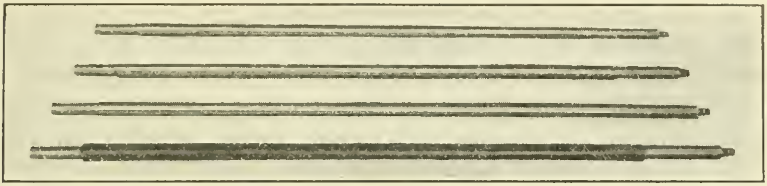

Fig. 3 Work too Slim to Turn before Grinding

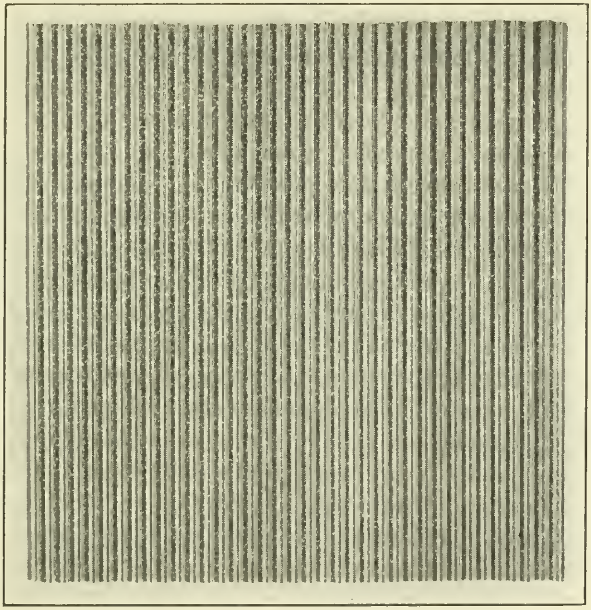

Fig. 4 Work Ground without Turning

work should then go to a lathe where a more skillful operator can locate the shoulders exactly; if a sharp corner is really necessary it can then be made.

33 Fig. 3 shows work so slim that turning of the main portion is out of the question if it is to be produced efficiently. The

main or center portion should be ground direct without turning.

34 Fig. 4 shows 37 slim shafts ground direct from the black stock. To turn them first would be a waste of time. They were 30 in. long, 11/16 in. in diameter in the rough, ground to 0.625 in. plus or minus 0.0005 in.; handled twice and ground complete in 17 minutes each. These were tool steels.

35 A lot of 60 countershafts, 35 point carbon steel, finish size 2 3/16 in. plus or minus 0.0005 in. by 66 in. long, turned 8 pitch, leaving about 1/32 in. for grinding; ground complete at the rate of 35 minutes each; cubic inches ground off, 278; cubic inches of steel removed for every cubic inch of wheel wear, 20.7; total cost of wheel for 60 shafts, 38 cents; total cost of power, 35 cents; wheel used, 24 combination grade L alundum; radial depth of cut, when roughing, 0.001 in.; radial depth of cut, when finishing, 0.0005 in.; surface speed of work, roughing, 42 ft. per min.; surface speed of work, finishing, 35 ft. per min.; table traverse, roughing, 11 ft. per min.; table traverse, finishing, 10 ft. per min.; steady-rests "multiple system."

36 To produce cylindrical work efficiently we must make a study of all that affects the problem in each individual case instead of following tradition which is costing us thousands of dollars each year. Lathe builders are offering some very efficient roughing lathes, but are we roughing with them? I think not in most cases. The real roughing lathe needs a good system of multiple steadyrests to enable rapid and deep coarse cuts. Will someone come forward with such a system of steadyrests?

37 Instead of our lathe departments and grinding departments being separate as is common now, there should be one department of cylindrical work under one head. This would check the tendency of the lathe department to treat their work as a finished product, and the tendency of the grinding department to insist upon close careful turning in order to make a better showing of the grinding time, regardless of the real cost of production.

38 There is much yet to be learned about the preparation for grinding of cylindrical work; no two pieces of work require the same lathe treatment. There is a great need for thinking men as foremen and operators. Such men can effect great savings by working out in each case the best combination of turning and grinding of cylindrical work.

THE STRENGTH OF GEAR TEETH

By Guido H. Marx

ABSTRACT

The experiments recorded in this paper were made with a view to securing data upon the allowable unit fiber stress for cast iron gear teeth when in operation. The gears tested were all of 10 diametral pitch, 14½-deg. involute, $1\frac{1}{16}$-in. face. Comparison is made of these results and of those given by the use of the Lewis formula, together with a discussion of such discrepancies as were found to exist. Factors such as arc of action and width of face were found to exert an influence in ways not usually taken account of. Practical suggestions are given upon the proportions of gears based upon the observed manner of breaking of the various gears tested.

THE STRENGTH OF GEAR TEETH

By Guido H. Marx, Stanford University, Cal.

Member of the Society

The teeth of gear wheels when transmitting power are individually subjected to an action akin to that applied to a beam fixed at one end, with a load somewhere between the fixed and the free ends. All standard formulae or diagrams for the proportioning of such teeth therefore involve a factor representing the allowable unit fiber stress in a cantilever beam subjected to a bending moment.

2 The experiments described in this paper were undertaken with the primary purpose of throwing some light, if possible, upon the question of this allowable unit fiber stress for cast-iron gear teeth under operating conditions, since definite data upon this point have been lacking, particularly with reference to the effect of pitch line velocity. To this vital lack, attention has been called repeatedly by writers upon the subject of gearing.

3 Thus, in Wilfred Lewis's well-known Investigation of the Strength of Gear Teeth[1] occurs the following statement bearing upon this matter:

> What fiber stress is allowable under different circumstances and conditions cannot be definitely settled at present, nor is it probable that any conclusion will be acceptable to engineers unless based upon carefully made experiments. In the article referred to[2] certain factors are given as applicable to certain speeds and, in the absence of any later or better light upon the subject, Table II has been constructed to embody in convenient form the values recommended.

[1] Proceedings of the Engineers' Club, Philadelphia, 1893, vol. 10; also American Machinist, May 4, 1893.

[2] Power Transmitting Mechanism: On the Strength of the Teeth of Wheels, J. H. Cooper, Journal of the Franklin Institute, 1879.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

TABLE II SAFE WORKING STRESS S FOR DIFFERENT SPEEDS

Speed of Teeth, Ft. per Min.	100 or less	200	300	600	900	1200	1800	2400
Cast Iron.....	8000	6000	4800	4000	3000	2400	2000	1700
Steel........	20000	15000	12000	10000	7500	6000	5000	4300

It cannot be denied that slow speeds admit of higher working stresses than high speeds, but it may be questioned whether teeth running at 100 feet a minute are twice as strong as at 600 feet a minute, or four times as strong as the same teeth at 1800 feet a minute. For teeth which are perfectly formed and spaced, it is difficult to see how there can be a greater difference in strength than the well-known difference occasioned by a live load or a dead load, or two to one in extreme cases. But, for teeth as they actually exist, a greater difference than two to one may easily be imagined from the noise sometimes produced in running, and it should be said, that this table is submitted for criticism rather than for general adoption.

4 It is very evident that Mr. Lewis only offered the values of his Table II tentatively. A careful examination of Mr. Cooper's paper fails to disclose any table from which Table II is immediately transferred, but on page 15 of that paper will be found a series of factors, credited to E. R. Walker, New Castle-under-Lyme, 1868, varying with the rim-speed of wheels, by which the "breaking load of tooth" is to be divided. These factors are given as follows:

m = 3 for very slow speed without shock.
= 4 when rim of wheel runs 3 ft. per sec.
= 5 when rim of wheel runs 5 ft. per sec.
= 6 when rim of wheel runs 10 ft. per sec.
= 8 when rim of wheel runs 15 ft. per sec.
= 10 when rim of wheel runs 20 ft. per sec.
= 12 when rim of wheel runs 30 ft. per sec.
= 14 when rim of wheel runs 40 ft. per sec.

It will be seen that these values correspond to Mr. Lewis's table if 24,000 and 60,000 lb. per sq. in. are used for the ultimate fiber stress in flexure of cast iron and steel respectively. This is an apparent oversight on Mr. Lewis's part. While 24,000 lb. per sq. in. is a legitimate assumption for the unit strength of cast iron in tension, a value of at least 36,000 may be taken ordinarily for the modulus of rupture for transverse stress or ultimate unit stress in outer fiber, due to bending. That Mr. Cooper meant this modulus of rupture by "breaking stress" is obvious from pages 8 to 11 of his paper. He also quotes J.

Christie as using a modulus of rupture of 36,000, with a factor of safety of never less than 4, and then under the most favorable conditions, as well-fitted gears, rigidly supported, running at moderate speed, and stress evenly distributed. For strains suddenly applied the factor of safety should be 6, and when accompanied by severe shocks and sudden reversions of strains it should be 8. With these assumptions, for cast-iron teeth, Mr. Christie would allow for safe working stresses from $\frac{36000}{4}$ = 9000 lb. per sq. in., down to $\frac{36000}{8}$ = 4500 lb. per sq. in., as contrasted to a range in Table II of from 8000 lb. down to 1700 lb.

5 In view of the fact that Mr. Christie gives several examples from practice to sustain his position, and of Mr. Lewis's own doubt as expressed in the foregoing quotation from his paper, of so wide a range being justified as that called for by his Table II, and of the further fact that this table was based upon a modulus of rupture much too low, it seems strange that these tentative values have been so generally accepted; and the need of adequate experimental data becomes apparent.

6 Mr. Cooper on page 9 of his paper says:

> It is certainly necessary to know the strain that breaks a piece of projecting cast-iron of given size and shape, when the stress is laid on quietly, as well as when it is driven on with considerable velocity.
>
> It is also important to know the fractional part of the rupturing weight or stress which may be repeatedly laid on with perfect safety, to insure the continuance of adhesion under the usual conditions of working. Upon these essential features of each case, the criteria, almost every engineer's guide book is silent.

7 A copy of Brown & Sharpe's Treatise on Gearing which the writer has had since 1892 gives the only data he recalls having seen of cut gears tested to rupture under running conditions. On page 118 is the following:

> We give a few examples of average breaking strain of our Combination Gears, as determined by dynamometer pressure taken at the pitch line.

Diametral Pitch	Face	No. of Teeth	R. P. M.	Pressure at Pitch Line
10	1 1/16	110	27	1060
8	1 1/4	72	40	1460
6	1 9/16	72	27	2220
5	1 7/8	90	18	2470

If we take a safe pressure at $^1/_3$ of the foregoing breaking strain we shall have

for 10 Pitch $353^1/_3$ lb. at the pitch line
8 Pitch $486^2/_3$ lb. at the pitch line
6 Pitch 740 lb. at the pitch line
5 Pitch $823^1/_3$ lb. at the pitch line

8 In order to add to the available data concerning the strength of modern, cut, cast-iron gear teeth under operating conditions, the writer had the apparatus shown in Fig. 1, constructed. It consists of a base-plate carrying three adjustable bearings. Only one of these is clearly seen in the immediate foreground of the illustration, but at its right can be seen a corner of a second, while the third is hidden by the brake wheel. The action of the apparatus, reduced to the utmost simplicity of construction, can be seen by reference to Fig. 2.

9 The motor, a 25-h.p. 220-volt, direct-current machine, is connected by a Morse chain to shaft No. 1. Shafts No. 1 and No. 2 are connected by a pair of cut-steel change gears of 8 diametral pitch which can be varied to give a wide range of velocity ratios. Shafts No. 2 and No. 3 are connected by the cast-iron, cut gears to be tested. On the outer end of shaft No. 3 there is a flanged, water-cooled brake wheel carrying a prony brake. The arm of the brake rests, by means of a steel knife edge and plate, on a platform scale. Each bearing is provided with a sight feed lubricator. The measurement of the efficiency of transmission not being the object of the experiment, the friction of the bearings is neglected. The only effect of this is to make the computed breaking load of the teeth a very little less than its real value in each case. By means of the slotted baseplate and the tongues on the bottom of the bearings, the latter can be slid into place, the gears accurately meshed without binding or backlash, and then securely held by means of two square-head bolts to each bearing. The Morse chain is lubricated with

a graphite and grease mixture, and the gears, both steel and cast-iron, with ordinary thick grease lubricant which was also freely used on the brake. Before starting each run a wooden guard was placed over the gears to be tested. That this was not a useless precaution was indicated by the fragmentary condition of the gears, particularly those having arms, at the conclusion of many of the runs.

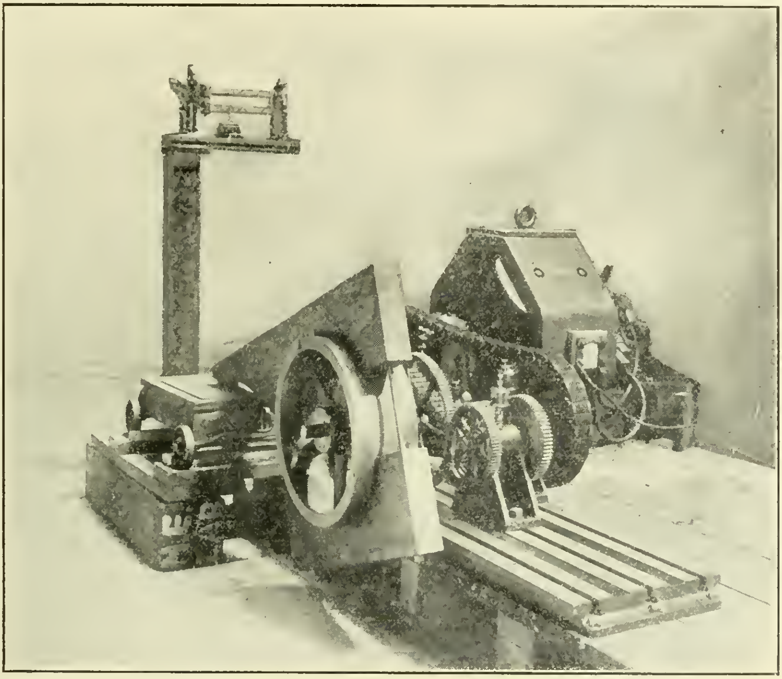

Fig. 1 General View of Testing Apparatus

10 The tests were made in the mechanical laboratory of the Leland Stanford Junior University. For each run the motor was started with zero load applied by the prony brake. The scale weights were then set at the lowest load and the brake tightened until the scale beam floated. Simultaneously the rate of rotation was observed with a tachometer which was calibrated upon completion of the tests and the necessary slight corrections made in the computed results. Calibration of the scales showed them to be entirely correct throughout the range used.

Increments of load on the scale began at 5 lb. each while the load was low, and were diminished to two lb. and one lb. as the probable breaking load was approached. The unexpectedly high breaking strength shown by the teeth[1], particularly at the higher velocities, made it impossible to break the gears at pitch speeds much exceeding 500 ft. per min. with this apparatus.

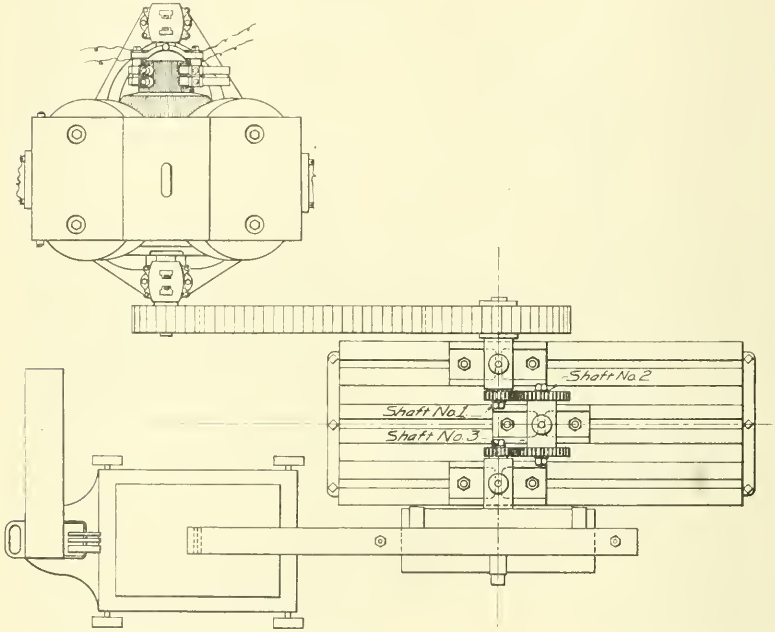

Fig. 2 Plan of Apparatus

At the higher speeds the teeth were capable, without rupture, of transmitting all of the power the motor could develop.

11 The gears tested were all 10 diametral pitch, cast-iron, 14½-deg. involute, purchased of the Brown & Sharpe Mfg. Co. without intimation of the special purpose for which they were intended, and were of the ordinary stock proportions. The width of face in all cases was 1 1/16 in. The 20- and 30-tooth gears were solid, the 40-tooth webbed, and the others each had six arms. The twenties and thirties had a bore of 1 1/16 in.

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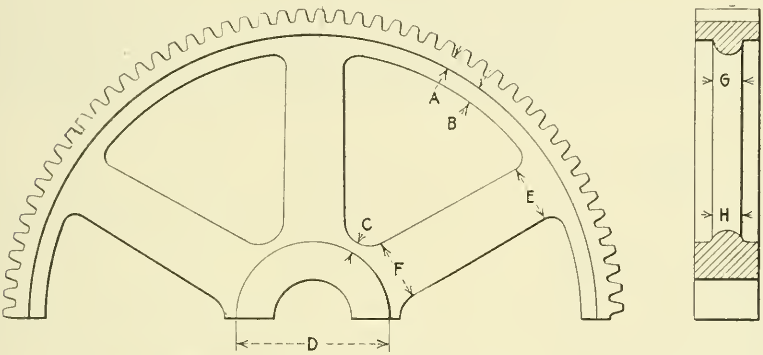
[1] Preliminary calculations had been based upon the Brown & Sharpe figures quoted in Par. 6.

and a ¼ in. keyway. The rest had a bore of 1 5/16 in. and a 5/16 in. keyway. The general proportions of the arm gears are shown in Fig. 3.

12 As shown by the logs, the main tests were conducted in two series; the first being made in 1911 with single observations under each set of conditions; and the second, made in 1912, being planned to cover the ground more completely, with the further intention of making three runs in each case under identically the same conditions in order to eliminate errors of observation and of variable material.



	A	B	C	D	E	F	G	H
60 T	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$2\frac{7}{16}$	$\frac{7}{8}$	$\frac{13}{15}$	$\frac{3}{8}$	$\frac{3}{8}$
80 T	$\frac{9}{32}$	$\frac{1}{4}$	$\frac{1}{4}$	$2\frac{7}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	$\frac{3}{8}$	$\frac{3}{8}$
100 T	$\frac{5}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$2\frac{1}{2}$	$\frac{7}{8}$	1	$\frac{7}{16}$	$\frac{15}{32}$
150 T	$\frac{3}{8}$	$\frac{9}{32}$	$\frac{5}{16}$	$2\frac{1}{2}$	$\frac{31}{32}$	$1\frac{3}{16}$	$\frac{1}{2}$	$\frac{17}{32}$

Note-All dimensions are in inches. Bore $1\frac{5}{16}$ in. Face $1\frac{1}{16}$ in. in all cases

FIG. 3 DIMENSIONS OF ARMS OF GEARS TESTED

13 Fig. 4 shows graphically the results of all the foregoing tests involving 20-tooth pinions. Abscissae are pitch-line speeds in feet per minute, and ordinates are forces at the pitch point equivalent to the breaking loads in pounds. This equivalent breaking load is, of course, equal to the net brake load at rupture by brake arm divided by the pitch line radius of gear on brake shaft. Curve *A* is drawn representing the results of all tests with 20- and 30-tooth gears in mesh. As there were several observations taken for each pitch speed, the numerical average

TABLE 1 TESTS OF 10 DIAMETRAL PITCH, CAST IRON, 14½ DEG. INVOLUTE GEARS
LOG OF FIRST SERIES OF RUNS

Test No.	Date, 1911	Gears Tested 10 Pitch, C. I.		Sprocket r.p.m. Observed Tachometer	Brake r.p.m. Observed Tachometer	Change Gears 8 Pitch, Steel		Final Net Brake Load, Lb.	Notes made at Conclusion of Each Test
		Driver	Driven			Sprocket Shaft	Intermediate Shaft		
01	June 5	20	150	...	260	120	20	110	Neither gear broken. Fuse blew and motor stopped. Intermediate shaft heated and seized; driven out, draw-filed; bearing scraped. The 5/16 in. machinery steel key of 120 T–8 pitch, steel change gear sheared off. Shaft replaced by new one in subsequent tests. Both 5/16-in. keys replaced by 1/2 in. This was trial run to test out apparatus.
02	June 9	20	100	...	375	120	20	125	Neither gear broken. Limit of motor power. Fuse blew.
03	June 9	20	100	355	...	20	120	240	Broke 3 teeth at root in 20–T pinion. Broke 100–T gear in 4 pieces. No teeth broken out of large gear, but rim broken.
04	June 9	20	30	353	...	20	120	71	Broke as load was being increased from 70 to 72 lb. Broke 20–T pinion in 3 pieces, each running to the bore; no teeth broken at root. Apparently gave way at key-way. Broke 1 tooth at root in 30–T gear.
05	June 10	20	30	316	...	70	70	50	Broke 13 teeth at root in 20–T pinion. Also broke at key-way and into 3 pieces. Broke 8 teeth out of 30–T gear. Battered and loosened 1/4-in. key on intermediate shaft. Both 1/4-in keys replaced by hardened tool steel, same size. Probable that break occurred by "canting" of loosened key.
06	June 10	20	30	...	360	70	40	60	Broke 20–T pinion in 4 pieces, one at key-way. One tooth cracked at root. No break in 30–T gear. Broke as load was beginning to be raised from 60 lb. to next scale setting, 65 lb.

TABLE 1—Continued

07	June 10	20	30	...	480	70	30	55	The 30–T gear was the same one used in test No. 06. Broke 20–T pinion in 4 pieces, one being a single tooth with wedge running to key-way. Broke 7 teeth off at root. Also broke 7 teeth off at root in the 30–T gear.
08	June 12	20	30	...	218	70	70	60	This test was made as a repetition of No. 05, as that test seemed unreliable because it pointed to splitting by loose key. Broke 20-T pinion in 2 pieces; also broke out 10 teeth at root and cracked 2. Broke 3 teeth out of 30–T gear.
09	June 12	30	40	...	236	70	70	79	Broke 18 teeth of 30–T gear at root and crushed one from end. Broke 14 teeth at root of 40–T gear. Heard crack at 78 lb. load and stopped run. No teeth found broken. Started again and broke between 78 and 80 lb. load.
010	June 12	40	60	...	206	70	70	148	Broke 9 teeth out of 40–T gear and 9 teeth out of 60–T gear.
011	June 12	40	40	...	230	70	100	104	17 teeth stripped and 7 partially broken on 40–T driver. 10 teeth stripped and 2 partially broken on 40–T driven.
012	June 12	40	60	335	...	70	100	148	9 teeth stripped and 1 broken on 40–T gear. 6 teeth stripped out of 60–T gear.
013	June 12	40	80	326	...	70	100	222	8 teeth stripped out of 40–T gear. Note depth of break at bottom. Broke rim of 80–T gear in 4 pieces.
014	June 12	60	80	328	...	70	100	223	Broke between 222 and 224 lb. load. 21 teeth stripped out of 60–T gear. 80–T gear broken in 6 pieces and 8 teeth stripped.
015	June 13	80	100	315	...	40	100	280	No teeth broken out of either gear. 100–T gear broke at 3 places in rim, also broke out hub and arms at key-way. 5/16-in. key loose in key-way. It looks as if the yielding of the key-way in shaft allowed the key to cant slightly and split the hub. (See also tests Nos. 05 and 016). Key replaced with hardened tool-steel key. Strength of teeth not shown in this test.
016	June 13	30	150	328	...	40	100	380	30–T gear had 7 teeth stripped. 150–T gear very obviously wedged apart from hub outward by the key which was found canted so that one corner of the bottom was 5/64 in. from the bottom of key-way. (See tests Nos. 05 and 015). Large gear cracked at hub and rim, not broken apart.

TABLE 2 TESTS OF 10 DIAMETRAL PITCH, CAST IRON, 14½ DEG. INVOLUTE GEARS
COMPUTED RESULTS OF FIRST SERIES OF RUNS

SPEED CORRECTIONS MADE FOR ERROR OF TACHOMETER; BRAKE ARM = 32 IN.; ZERO BRAKE LOAD = 3½ LB., BALANCED ON UPPER SCALE-BEAM

Test No.	TEETH IN GEARS				Correct r.p.m. Brake Gear	Pitch Circumference in Ft. Brake Gear	Net Brake Load in Lb.	Pitch Speed Brake Gear, Ft. per Min.	Equivalent Load at Teeth, in Lb.	Remarks
	Change Gears		Tested Gears							
	Sprocket 8 p. Steel Driver	Intermediate 8 p. Steel Driven	Intermediate 10 p. C. I. Driver	Brake 10 p. C. I. Driven						
01	120	20	20	150	266.0	3.927	110	1044.6	469	Gears not broken. Motor stalled. Run does not count.
02	120	20	20	100	384.0	2.618	125	1005.3	800	Gears not broken. Motor stalled. Run does not count. Demonstrates that teeth are stronger than this.
03	20	120	20	100	12.13	2.618	240	31.76	1536	Reliable run.
04	20	120	20	30	40.22	0.7854	71	31.61	1515	Reliable run.
05	70	70	20	30	215.3	0.7854	50	169.23	1067	Indicates that gear broke as suspected (see Log, Table 1) by canting of key. Repeated in test No. 08
06	70	40	20	30	369.0	0.7854	60	290.03	1280	Reliable run.
07	70	30	20	30	493.0	0.7854	55	387.5	1173	Reliable run
08	70	70	20	30	223.0	0.7854	60	175.38	1280	Reliable run takes place of test No. 05, of which it was a duplicate but with new key
09	70	70	30	40	241.0	1.047	79	252.33	1264	Reliable run
010	70	70	40	60	210.5	1.571	148	330.7	1579	Reliable run
011	70	100	40	40	235.0	1.047	104	246.05	1664	Reliable run
012	70	100	40	60	160.7	1.571	148	252.46	1579	Reliable run
013	70	100	40	80	116.9	2.094	222	244.79	1776	Reliable run
014	70	100	60	80	176.4	2.094	223	369.38	1784	Reliable run
015	40	100	80	100	103.0	2.618	280	269.65	1792	No teeth broken. Shows these teeth are stronger than even this
016	40	100	30	150	26.9	3.927	380	106.64	1621	Indicates further that gear broke (see Log, Table 1) by canting of key

TABLE 3 TESTS OF 10 DIAMETRAL PITCH, CAST IRON, 14½ DEG. INVOLUTE GEARS
LOG OF SECOND SERIES OF RUNS

Test No.	Date, 1912	Gears Tested 10 Pitch, Cast Iron		Motor r.p.m. Observed Tacho-meter	Brake r.p.m. Observed Tacho-meter	Change Gears 8 Pitch, Steel		Final Net Brake Load, Lb.	Notes made at Conclusion of Each Test
		Driver	Driven			Sprocket Shaft	Inter-mediate Shaft		
1	May 4	20	30	420	...	20	120	68	20-T pinion broke at key-way; 3 pieces, and 1 tooth broken out at root. Broke 1 tooth out of 30-T gear
2	May 4	20	30	422	...	20	120	78	20-T pinion broke at key-way; 3 pieces, and 1 tooth broken out at root. Broke 1 tooth out of 30-T gear
3	May 4	20	30	422	...	20	120	76	20-T pinion broke at key-way; 3 pieces, and 1 tooth broken out at root. Broke 1 tooth out of 30-T gear
4	May 4	20	30	410	...	70	70	62	20-T pinion broke at key-way; 3 pieces, and 14 teeth broken out at root. Broke 5 teeth out of 30-T gear
5	May 4	20	30	414	...	70	70	58	20-T pinion broke at key-way; 5 pieces, and 4 teeth broken out at root. Broke 5 teeth out of 30-T gear
6	May 4	20	30	414	...	70	70	60	20-T pinion broke at key-way; 3 pieces, and no teeth broken out at root. 30-T gear not broken at all
7	May 9	20	30	450	...	100	40	52	Neither gear broke. Fuse blew. Motor stalled. Made new electrical connections at higher voltage
8	May 11	20	30	...	520	100	40	52	Same gears as test 7. 20-T pinion broke at key-way; 5 pieces, and 1 tooth broken out at root. 30-T not broken
9	May 11	20	30	...	540	100	40	58	20-T pinion broke at key-way; 5 pieces, and 1 tooth broken out at root. 30-T gear not broken
10	May 11	20	30	...	550	100	40	58	20-T pinion broke at key-way; 4 pieces, and 1 tooth broken out at root. 30-T gear not broken
11	May 11	20	30	...	660	120	40	54	20-T pinion broke at key-way; 4 pieces, and 1 tooth broken out at root. 30-T gear not broken
12	May 11	20	30	...	660	120	40	60	20-T pinion broke at key-way; 4 pieces. No teeth broken out of either gear. Note strength of teeth indicated

TABLE 3—Continued

Test No.	Date, 1912	Gears Tested 10 Pitch, Cast Iron		Motor r.p.m. Observed Tacho-meter	Brake r.p.m. Observed Tacho-meter	Change Gears 8 Pitch, Steel		Final Net Brake Load, Lb.	Notes made at Conclusion of Each Test
		Driver	Driven			Sprocket Shaft	Inter-mediate Shaft		
13	May 11	20	30	...	660	120	40	52	20–T pinion broke at key-way; 4 pieces, and 3 teeth broken out at root. 30–T gear not broken
14	May 11	20	30	680	...	120	30	48	Did not break gears. Too fast for brake. Abandoned attempt to make runs at this speed
15	May 11	20	30	...	400	70	40	52	Same gears as test 14. Broke before the scales quite balanced at 52 lb. setting. 20–T pinion broke at key-way; 4 pieces, and 1 tooth broken out at root. 30–T gear not broken
16	May 11	20	30	...	396	70	40	54	Same gears as test 14. Broke before the scales quite balanced at 52 lb. setting. 20–T pinion broke at key-way; 4 pieces, and 1 tooth broken out at root. 30–T gear not broken
17	May 11	20	30	...	400	70	40	56	Same gears as test 14. Broke before the scales quite balanced at 52 lb. setting. 20–T pinion broke at key-way; 2 pieces, and 15 teeth broken out at root. 30–T gear 1 tooth at root. 56 lb. load barely reached
18	May 11	30	40	700	...	20	120	116	30–T gear 14 teeth out at root. 40–T gear 3 teeth out at root
19	May 11	30	40	720	...	20	120	120	30–T gear 8 teeth out at root. 40–T gear 3 teeth out at root
20	May 11	30	40	710	...	20	120	123	30–T gear 11 teeth out at root. 40–T gear 3 teeth out at root, and 1 broken
21	May 11	30	40	715	...	70	100	112	30–T gear 13 teeth stripped and 7 broken. 40–T gear 6 teeth stripped, 2 broken, 2 cracked at root
22	May 15	30	40	690	...	70	100	108	30–T gear 18 teeth stripped. 40–T gear 8 teeth stripped

TABLE 3—Continued

23	May 15	30	40	720	...	70	100	106	30–T gear 11 teeth stripped and 1 broken. 40–T gear 9 teeth stripped
24	May 15	30	40	720	...	70	70	102	30–T gear 28 teeth stripped and 1 broken. 40–T gear 15 teeth stripped
25	May 15	30	40	720	...	70	70	102	30–T gear 11 teeth stripped and 2 broken. 40–T gear 9 teeth stripped
26	May 15	30	40	720	...	70	70	103	30–T gear 16 teeth stripped and 1 broken. 40–T gear 15 teeth stripped and 1 broken
27	May 15	30	40	720	...	70	40	92	Neither gear broken. Circuit breaker out. Motor stopped
28	May 15	30	40	710	...	70	40	98	30–T gear had all teeth stripped. 40–T gear 14 teeth stripped and 1 broken
29	May 15	30	40	710	...	70	40	96	Neither gear broken. Circuit breaker out. Motor stopped
30	May 15	30	40	680	...	70	40	100	Neither gear broken. Circuit breaker out. Motor stopped
31	May 15	30	40	680	...	70	40	102	Neither gear broken. Circuit breaker out. Motor stopped. No use trying to break at this speed. Limit of motor. Same gears used in tests 29, 30 and 31; practically one run
32	May 15	30	40	720	...	100	70	108	Same gears used as in tests 29, 30 and 31. 30–T gear had 24 teeth stripped and 1 broken. 40–T gear had 19 teeth stripped
33	May 15	30	40	720	...	100	70	104	30–T gear had all teeth stripped. 40–T gear had 21 teeth stripped and 3 broken
34	May 15	30	40	720	...	100	70	106	30–T gear had all teeth stripped. 40–T gear had 19 teeth stripped. 106 lb. load barely reached
35	May 15	30	60	720	...	70	70	154	30–T gear had 16 teeth stripped. 60–T gear had 8 teeth stripped
36	May 15	30	60	720	...	70	70	156	30–T gear had 16 teeth stripped and 2 broken. 60–T gear had 5 teeth stripped, 1 broken
37	May 15	30	60	720	...	70	70	150	30–T gear had 20 teeth stripped. 60–T gear had 6 teeth stripped
38	May 16	30	80	710	...	70	70	202	Intermediate bearing slipped, allowing load to come on ends of teeth. 30–T gear stripped 6 teeth. 80–T gear stripped 2 teeth
39	May 16	30	80	725	...	70	70	204	30–T gear stripped 5 teeth. 80–T gear stripped 1 tooth; broke into 3 pieces, split at key-way

TABLE 3—Continued

Test No.	Date, 1912	Gears Tested 10 Pitch, Cast Iron		Motor r.p.m. Observed Tacho-meter	Brake r.p.m. Observed Tacho-meter	Change Gears 8 Pitch, Steel		Final Net Brake Load, Lb.	Notes made at Conclusion of Each Test
		Driver	Driven			Sprocket Shaft	Inter-mediate Shaft		
40	May 16	30	80	720	...	70	70	206	30–T gear not broken at all. No teeth broken out of 80–T gear; broken into 2 pieces, split at key-way. Key-way found enlarged and key had to be reset by calking more than usual amount
41	May 16	30	100	720	...	70	70	250	Same 30–T gear as used in test 40. Again not broken at all. No teeth broken out of 100–T gear, which broke into 4 pieces; split at key-way. Not necessary to try any more of these as they split at key-way. Try later the "German" key
42	May 16	30	30	720	...	70	70	72	Same 30–T gear as driver as used in tests 40 and 41; stripped 20 teeth and broke 1. Driven 30–T gear stripped 26 teeth
43	May 16	30	30	720	...	70	70	70	Driver 30–T gear stripped 24 teeth and broke 1. Driven 30–T gear stripped 24 teeth
44	May 16	30	30	720	...	70	70	68	Driver 30–T gear stripped 21 teeth and broke 1. Driven 30–T gear stripped 23 teeth
45	May 21	30	80	720	...	70	70	198	"German" key used. Same 30–T gear used as in test 6; one tooth broken or jambed. 80–T gear broken into 4 pieces, split at key-way. Key, obviously too high, canted. Ground off 1/32 in. of top. No teeth stripped
46	May 21	30	100	720	...	70	70	246	"German" key used. Same 30–T gear used as in test 6; not broken at all. 100–T gear broken into 6 pieces, split at key-way. No teeth stripped
47	May 21	40	40	720	...	30	40	114	Driver 40–T gear stripped all teeth. Driven 40–T gear stripped 12 teeth and broke 2. "German" keys used

TABLE 4 TESTS OF 10 DIAMETRAL PITCH, CAST IRON, 14½ DEG. INVOLUTE GEARS
COMPUTED RESULTS OF SECOND SERIES OF RUNS

Speed Corrections made for Error of Tachometer. Brake Arm = 32 In. Zero Brake Load = 3.5 Lb., Balanced on Upper Scale-Beam

Test No.	Teeth in Gears				Correct r.p.m. Brake Gear	Pitch Circumference in Ft. Brake Gear	Net Brake Load in Lb.	Pitch Speed Brake Gear, Ft. per Min.	Equivalent Load at Teeth, in Lb.	Remarks
	Change Gears		Tested Gears							
	Sprocket 8 p. Steel Driver	Intermediate 8 p. Steel Driven	Intermediate 10 p. Cast Iron Driver	Brake 10 p. Cast Iron Driven						
1	20	120	20	30	24.6	0.7854	68	19.32	1451	Reliable run
2	20	120	20	30	24.7	0.7854	78	19.40	1664	Reliable run
3	20	120	20	30	24.7	0.7854	76	19.40	1621	Reliable run
4	70	70	20	30	143.96	0.7854	62	113.07	1323	Reliable run
5	70	70	20	30	145.5	0.7854	58	114.28	1237	Reliable run
6	70	70	20	30	145.5	0.7854	60	114.28	1280	Reliable run. No teeth broken out of either gear
8	100	40	20	30	534.0	0.7854	52	419.40	1109	Reliable run. Tests Nos. 8–47 inclusive made at higher voltage than tests Nos. 1–7 inclusive
9	100	40	20	30	555.0	0.7854	58	435.90	1237	Reliable run
10	100	40	20	30	565.0	0.7854	58	443.75	1237	Reliable run
11	120	40	20	30	660.0	0.7854	54	518.36	1152	Reliable run
12	120	40	20	30	660.0	0.7854	60	518.36	1280	Reliable run. No teeth broken out of either gear
13	120	40	20	30	660.0	0.7854	52	518.36	1109	Reliable run
14	120	30	20	30	931.2	0.7854	48	731.36	1024	Nothing broken. Runs at this speed stopped. Too fast for brake
7	100	40	20	30	395.4	0.7854	52	310.55	1109	Nothing broken. Motor stalled. New electrical connections made
15	70	40	20	30	410.0	0.7854	52	322.01	1109	Reliable run, but load was probably a little less than 1109 lb. See Log, Table 3
16	70	40	20	30	406.0	0.7854	54	318.87	1152	Reliable run

TABLE 4—Continued

Test No.	Teeth in Gears				Correct r.p.m. Brake Gear	Pitch Circumference in Ft. Brake Gear	Net Brake Load in Lb.	Pitch Speed Brake Gear, Ft. per Min.	Equivalent Load at Teeth, in Lb.	Remarks
	Change Gears		Tested Gears							
	Sprocket 8 p. Steel Driver	Intermediate 8 p. Steel Driven	Intermediate 10 p. Cast Iron Driver	Brake 10 p. Cast Iron Driven						
17	70	40	20	30	410.0	0.7854	56	322.01	1195	Reliable run, but load was probably a little less than 1195 lb. See Log, Table 3
18	20	120	30	40	44.93	1.047	116	47.05	1856	Reliable run
19	20	120	30	40	46.24	1.047	120	48.42	1920	Reliable run
20	20	120	30	40	45.59	1.047	123	47.72	1968	Reliable run
21	70	100	30	40	192.76	1.047	112	201.86	1792	Reliable run
22	70	100	30	40	186.02	1.047	108	194.80	1728	Reliable run
23	70	100	30	40	194.78	1.047	106	203.97	1696	Reliable run
24	70	70	30	40	277.3	1.047	102	290.39	1632	Reliable run
25	70	70	30	40	277.3	.....	102	290.39	1632	Reliable run
26	70	70	30	40	277.3	.....	103	290.39	1648	Reliable run
27	70	40	30	40	.....	1.047	92	.....	....	Neither gear broken. Motor stalled. Circuit breaker reset for heavier current
28	70	40	30	40	478.53	1.047	98	501.12	1568	The three following runs indicate that this is probably faulty. Same gears used as in test No. 27
29	70	40	30	40	.....	1.047	96	.....	....	Neither gear broken. Motor stalled. Circuit breaker reset for heavier current. Same gears used
30	70	40	30	40	.....	1.047	100	.....	....	Neither gear broken. Motor stalled. Circuit breaker reset for heavier current. Same gears used
31	70	40	30	40	458.48	1.047	102	480.12	1632	Neither gear broken. Motor stalled. Abandoned attempt to run at this speed. Same gears used

TABLE 4—Continued

32	100	70	30	40	396.14	1.047	108	414.84	1728	Reliable run
33	100	70	30	40	396.14	1.047	104	414.84	1664	Reliable run
34	100	70	30	40	396.14	1.047	106	414.84	1696	Reliable run
35	70	70	30	60	184.86	1.571	154	290.38	1643	Reliable run
36	70	70	30	60	184.86	1.571	156	290.38	1664	Reliable run
37	70	70	30	60	184.86	1.571	150	290.38	1600	Reliable run
38	70	70	30	80	136.72	2.094	202	286.35	1616	Reliable run, except that bearing slipped allowing load to come on ends of teeth, hence 1616 lb. load is too low
39	70	70	30	80	139.61	2.094	204	292.40	1632	Reliable run
40	70	70	30	80	138.65	2.094	206	290.39	1648	Reliable run, but no teeth were stripped
45	70	70	30	80	138.65	2.094	198	290.39	1584	Unreliable run. Gear split. No teeth stripped. "German" key; see Log, Table 3
41	70	70	30	100	110.92	2.618	250	290.39	1600	Unreliable run. Gear split. No teeth broken. See log, Table 3
46	70	70	30	100	110.92	2.618	246	290.39	1574	Unreliable run. Gear split. No teeth broken. See Log, Table 3, "German" key
42	70	70	30	30	369.73	0.7854	72	290.39	1536	Reliable run
43	70	70	30	30	369.73	0.7854	70	290.39	1493	Reliable run
44	70	70	30	30	369.73	0.7854	68	290.39	1451	Reliable run
47	30	40	40	40	277.30	1.047	114	290.33	1824	Reliable run

of the equivalent breaking loads was taken for each set, and the curve drawn through these average points as near as might be.

14 In Fig. 4 the curve was extended by inference to the zero velocity line. It will be noted that this breaking load curve falls off with increase of speed up to a pitch velocity of something less than 300 ft. per min. and then apparently starts to rise again as though the maximum percussive effect had been passed. This fact, and the further one that within the limits of the actual tests the range of average breaking load was only from 1579 lb. at 19.4 ft. per min. down to 1169 lb. at 312.7 ft. pitch velocity, about 25 per cent, are two of the most striking points appearing in this investigation.

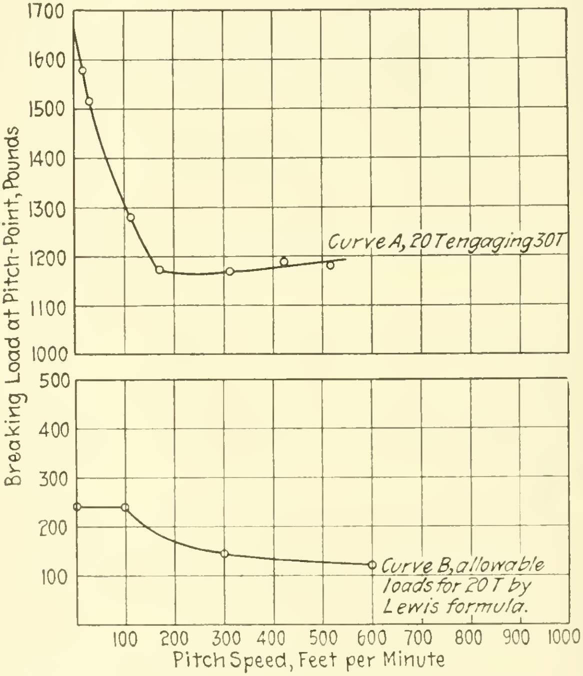


Fig. 4 Results of Tests with 20-Tooth Pinions

15 These phenomena might be questioned on the score that all of the 20-tooth gears but one broke entirely apart as well as having teeth stripped. But Fig. 5 shows the same general form for all tests involving 30- and 40-tooth gears in mesh;

and in this case there can be no question of anything but the strength of the teeth themselves, as it was only at the teeth that any of these gears broke.

16 It is an unfortunate fact that the limit of the motor's power was such as to make it impossible to rupture gears at higher speeds, thus enabling us to follow the curve and observe whether the apparent rise in breaking strength continued with increase in pitch speed. No attempt has been made to make this a smooth curve; the points corresponding to the averages obtained by experiment have merely been joined.

17 It is clear, however, even from these somewhat limited experiments, that the impact or percussive effect with increase of speed is not nearly so great, with these modern, accurately cut gears, as has commonly been supposed. In both cases the curves show that the minimum breaking strength (at a pitch speed of about 300 ft. per minute) is more than seven-eighths that at a pitch speed of about 100 ft. per min. and more than seven-tenths that at zero pitch speed. And it is not theoretically impossible that the breaking load actually rises with increase of speed, after a certain critical speed has been passed, until it would approximate the static breaking load if it were not for the increasing tendency of the teeth to tear loose due to centri-

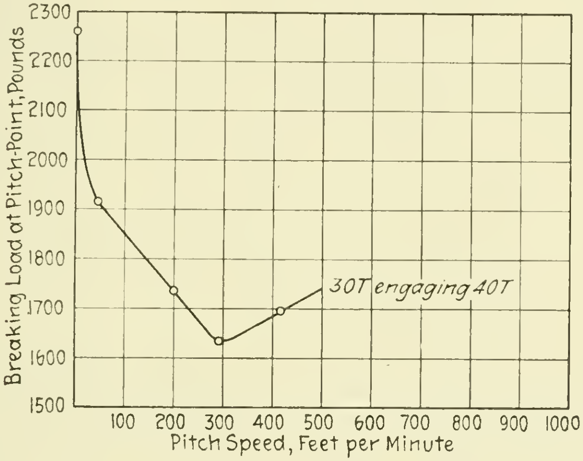


Fig. 5 Results of Tests with 30 and 40-Tooth Gears

fugal force. At an infinite speed the repetitive stress would become a continuous one. As Curve *A*, Fig. 4 shows the actual breaking strength of 20 teeth, 10 pitch, cast-iron gears at different speeds, it is interesting to compare with this the allowable loads for such gears computed for the same speeds by the Lewis formula (see Appendix No. 1). Curve *B*, expressing these, is shown at the bottom of Fig. 4. The discrepancy between the two curves is obvious. They do not even have the same general form.

18 From Par. 4 it is seen that Mr. Lewis's formulae and tables were intended to provide a factor of safety of 3 for pitch speeds of 100 ft. per min. or less, of 5 for 300 ft., and 6 for 600 ft., the differences being intended to cover presumed increases in impact effect. Using Mr. Lewis's accepted formula for 15-deg. involute teeth as being applicable to the Brown & Sharpe standard 14½-deg. involute teeth, namely,

$$W = s\ p\ f\ 0.124 - \frac{0.684}{n}$$

W = working strength of tooth
s = working stress of material per sq. in.
p = pitch of teeth in inches
f = face of teeth in inches
n = number of teeth,

Table 5 has been prepared to show the relation between the computed working strength and the actual breaking loads for the 20 and 30 tooth gears within the range of these experiments as shown by the plotted curves on their legitimate inferential extension.

19 When the actual breaking loads under running conditions have been determined, as they have in the above cases, the results provide the allowances for pitch-speed variations and it is difficult to see any reason for not using a uniform factor of safety for conditions which are uniform in other regards than pitch-speeds, to provide for the possibilities of faulty material, poor alignment, sudden applications or reversals of stress, and possible overloads. Just how great this factor need be is a question to be settled by the designer in each individual case. But in any case it would be a true factor of safety and not a factor of ignorance.

20 Mr. Lewis's Table II may be looked upon as a table of

TABLE 5 RELATION BETWEEN COMPUTED WORKING STRENGTH AND BREAKING LOADS 20- AND 30-TOOTH GEARS

20T In Mesh With 30T	Pitch	Speed	Ft. per min.	
	0	100	300	600
Computed Working Load, Lewis's Formula	240	240	144	120
Actual Breaking Load, Tests	1660	1310	1165[1]	1165[1]
Corresponding Factor of Safety	6.9	5.5	8.1	9.7
Working Load, Factor of Safety =4	413	340	290	290
30T In Mesh With 40T				
Computed Working Load, Lewis's Formula	270	270	163.2	135
Actual Breaking Load, Tests	2260	1850	1640	1640[1]
Corresponding Factor of Safety	8.4	6.9	10	12.2
Working Factor of Safety =4	565	463	410	410

[1] Neglecting apparent rise in curve.

TABLE 6.—VELOCITY COEFFICIENTS

Pitch Velocity, Ft. per Min.	000	100	150	200	300	400	500
Ratio $\frac{\text{Breaking Load at Given Vel.}}{\text{Breaking Load at Zero Vel.}}$ Data from Fig. 4	$\frac{1660}{1660}=1.0$	$\frac{1310}{1660}=0.789$	$\frac{1205}{1660}=0.725$	$\frac{1165}{1660}=0.702$	$\frac{1165}{1660}=0.702$	$\frac{1175}{1660}=0.707$	$\frac{1185}{1660}=0.712$
Ratio $\frac{\text{Breaking Load at Given Vel.}}{\text{Breaking Load at Zero Vel.}}$ Data from Fig. 5	$\frac{2260}{2260}=1.0$	$\frac{1850}{2260}=0.819$	$\frac{1790}{2260}=0.792$	$\frac{1735}{2260}=0.768$	$\frac{1640}{2260}=0.726$	$\frac{1680}{2260}=0.743$	$\frac{1740}{2260}=0.770$
v—Velocity Coefficient, Safe	1.00	0.80	0.75	0.72	0.70	0.68	0.66

factors representing a combination of the modulus of rupture, a factor of safety, and a coefficient depending upon velocity. It would seem better to separate these. The value of the modulus of rupture is discussed in Par. 24. For values to be taken for the factor of safety the writer agrees with Mr. Christie as quoted in Par. 4.

21 The values of the coefficient to provide for the effect of pitch-velocity v can be determined from the results of the tests shown in Fig. 4, Curve *A* and Fig. 5. These results are expressed in Table 6, together with a series of values of v based upon them and so selected as to lean toward the side of extra safety.

22 To check the material of the gears used in these tests and to determine whether it was normal or of exceptional strength, 24 test specimens were cut from 12 of the 30-tooth gears, selected at random, as shown in Fig. 6. These specimens were about ¼ in. thick, 11/16 in. wide and 2¼ in. long. Seventeen similar specimens were cut from castings made in the university's foundry and known to be of ordinary composition and quality. The specimens were all tested in flexure with the load aplied at the middle of a span of 1¾ in. The data and results of these tests are given in full in Table 7. The modulus of rupture of the gear material test pieces was 38,737 lb., while that of the check specimens was 39,049 lb. It is legitimate to conclude that the material of the gears used in these tests, while of first-rate quality, was not unusual or exceptional. The results of the tests may therefore be accepted as representing typical material. In general a value of 36,000 may be reasonably used for the modulus of rupture for cast-iron gear teeth.

23 The Lewis formula is based upon the theory of flexure under the assumptions that the entire load is borne by a single tooth, the point of application of the load being the extreme end of the tooth, and the direction of the acting force being normal to the tooth profile at that point. The line of action of the force is considered carried to the center line of the tooth (Fig. 7) with W equal to the transverse component as applied at this point. Subsequently it treats W as the load at the pitch circumference. The effects of the compressive and shear components are ignored. Fracture is assumed to take place on a plane section, the position of which is determined by inscribing a parabola of uniform

strength with the vertex lying at the intersection of the center line of the tooth and the line of action of the force. The dangerous section is the plane section containing the points of tangency of the parabola with the tooth outline. That these assumptions are too severe or unfavorable for accurately cut gears is evident from the result of these tests, as will be shown later.

24 To check the applicability of the Lewis formula to the *form* of gear tooth employed in these experiments, the teeth of the 20, 30, 40, 80, 100 and 150 tooth 14½-deg. involute gears were carefully measured by gear-tooth micrometer calipers. They then, together with a theoretical rack tooth of the same system, were accurately drawn to a scale of 100 times full size. In these teeth, parabolas were inscribed by the Lewis method and the dangerous section located. The data and results are given in Appendix No. 2. The factors for strength do not seriously vary from those given by the Lewis expression[1] for 15-deg involute teeth, i.e., $0.124 - \frac{0.684}{n}$. If the assumptions of Par. 23 are

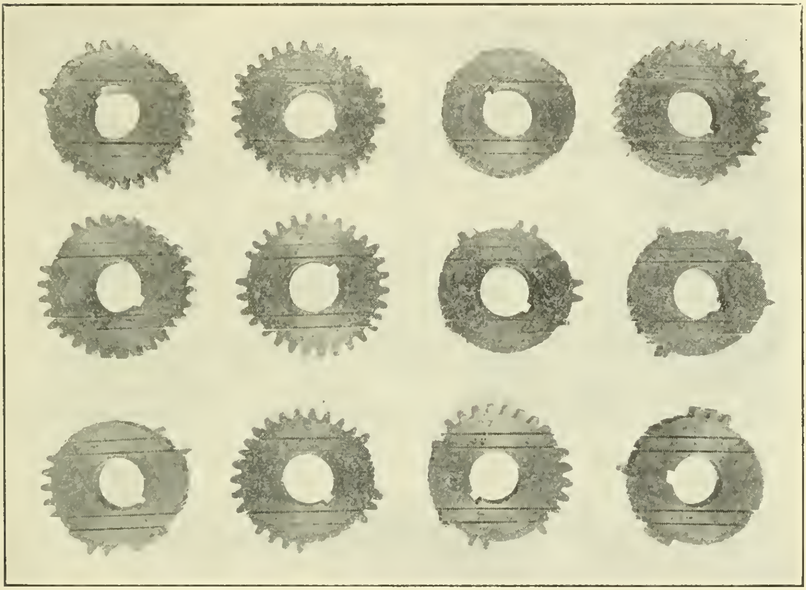


FIG. 6 METHOD OF OBTAINING TEST SPECIMENS

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[1] American Machinist, June 22, 1893.

TABLE 7 TESTS OF MATERIALS, DATA AND RESULTS, JUNE 26, 1912

Specimens Cut from Gears

Mark	Thickness	Width	Breaking Load at Mid-point	Corresponding Modulus of Rupture	Average Modulus of Rupture	Remarks.
05*A*	0.251	1.066	980	38305	....	
05*B*	0.251	1.065	975	38145	38225	
08*A*	0.251	1.065	1000	39123	....	
08*B*	0.251	1.063	1000	39196	39160	Small blow-hole on top.
09*A*	0.248	1.066	1167.5	46343	....	
09*B*	0.250	1.065	1197.5	47225	46784	
1*A*	0.251	1.063	917.5	35969	....	Small blow-hole on bottom.
1*A*	0.251	1.063	967.5	37922	36946	
17*A*	0.248	1.060	1106	44533	....	
17*B*	0.250	1.058	1156.5	45910	45222	
19*A*	0.245	1.060	950	39194	....	
19*B*	0.248	1.061	970	39020	39107	
28*A*	0.251	1.067	....	....	....	Flawed. No reading.
28*B*	0.251	1.067	850	33192	33192	
32*A*	0.251	1.060	1000	39307	....	
32*B*	0.250	1.061	995	39387	39347	
37*A*	0.251	1.06	895	35081	....	
37*B*	0.251	1.063	904	35434	35258	
39*A*	0.251	1.0635	842.5	33008	....	
39*B*	0.250	1.0635	870	34358	33683	
43.*A*	0.251	1.060	867.5	34099	....	
43.*B*	0.251	1.060	874	34355	34227	
43..*A*	0.251	1.056	1087.5	42909	....	
43..*B*	0.251	1.054	1125	44472	43691	
				Grand Aver.	38737	

Check Specimens, Ordinary Cast Iron

A	0.251	1.0615	1000	39252	....	
B	0.251	1.063	....	....	....	Broke before initial load,900lb
C	0.250	1.058	990	39300	....	
D	0.252	1.062	962.5	37463	....	
E	0.252	1.062	975	37862	....	
F	0.251	1.059	1000	39354	....	
G	0.252	1.062	920	35809	....	
H	0.248	1.059	990	39899	....	
I	0.257	1.062	1195	44720	....	
J	0.254	1.058	880	33842	....	
K	0.251	1.057	1018	40129	....	
L	0.247	1.061	842	34145	....	
M	0.245	1.064	....	....	....	Void. Flawed.
N	0.250	1.0625	1014	40083	....	
O	0.250	1.0625	1136	44905	....	
P	0.252	1.058	945	36930	....	
Q	0.252	1.062	1080	42037	....	
				Grand Aver.	39049	

Distance between supports = 1.75 in. in all cases.

correct, the Lewis formula should give the actual static breaking loads when the actual modulus of rupture is inserted for *s*.

25 To test this, consider first the case of a 20-tooth 10-pitch, 1 1/16 in. face, cast-iron pinion, the material having a modulus of rupture of 39,000. Substitution in the Lewis formula

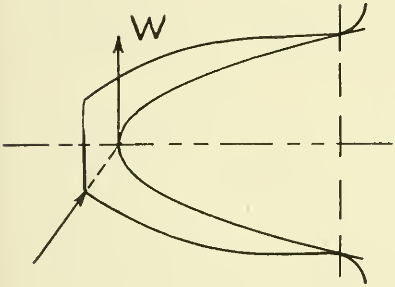
$$W = spf\ (0.124 - \frac{0.684)}{n}$$

gives

$$W = 39{,}000 \times 0.31416 \times 1.0625 \left(0.124 - \frac{0.684}{20}\right)$$

therefore

$$W = 1170 \text{ lb.}$$



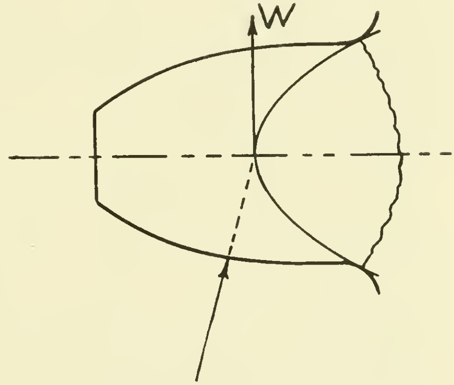


Fig. 7 Line of Force as Assumed in Lewis Formula

Fig. 8 Line of Force as Determined by Actual Fractures

But from Curve *A*, Fig. 4 it is seen that the static strength (i.e. equivalent breaking load at zero pitch velocity) is approximately 1650 lb. for a 20-tooth pinion in mesh with a 30-tooth gear. The value computed by the Lewis formula, when using the real modulus of rupture, is only two-thirds of the actual value shown by the tests. Similarly, the Lewis formula gives a value of 1317 lb. for the static breaking strength of the 30-tooth gear, while Fig. 5 shows this to be, for a 30-tooth meshing with a 40-tooth, 2260 lb. Again the Lewis value is much too low, being but 60 per cent of the actual test result.

26 These discrepancies demonstrate that the assumptions

upon which the Lewis formula are based are too severe and they indicate the necessity of taking into consideration the length of the arc of action; for if the length of the arc of action exceeds the pitch arc, it is evident that the previously engaging teeth will not have gone out of action at the time when the load first comes on the newly engaging teeth, and it is only at the instant of engagement or disengagement that the load can be applied at the end of a tooth. This is not only theoretically so but it can be counted on with reasonable certainty for modern, accurately cut gears. It must be borne in mind that this is the least stiff position of the tooth and that it would therefore tend to yield slightly under the load thus allowing another pair of teeth to come into engagement or remain in engagement. This elastic yielding would be apt to make up for the slight errors in tooth spacing. The mathematical discussion of the arc of action and its numerical determination for the gear combinations used in these experiments will be found in Appendix No. 3.

27 In order to test the actual static strength of the teeth in various positions, and with one, two or if possible, three pairs engaging simultaneously, experiments were carried out with results as shown in Table 8. The loads were applied in each case by a steel 30-tooth pinion with all teeth save three single ones, two pairs of two, and one set of three having been milled off in such a way as to leave gaps between the remaining teeth. Because of this there could be positive assurance that only as many pairs of teeth engaged in any test as was intended. The gears were set up with the teeth engaging in the position desired, the cast-iron gear to be tested being the one on the brake shaft and a surface gage being used to test the accuracy of conditions. All play was taken up and the brake was tightened down with emery cloth between it and the wheel so as to prevent all slip. The breaking power was supplied by means of a special hand-operated lever instead of by motor.

28 Position *A* corresponds to the loading assumptions of the Lewis formula and it is interesting to compare these results with those obtained by using the Lewis formula with a modulus of rupture of 39,000 lb. Table 9 presents this comparison in concise form.

TABLE 8. EQUIVALENT STATIC BREAKING LOADS *W* AT PITCH LINE—SERIES 4, SEPTEMBER 11-13, 1912

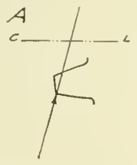
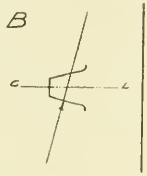
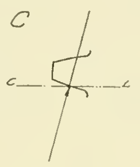
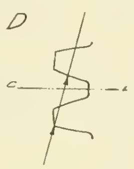
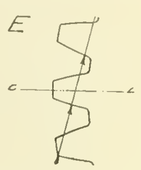
10-Pitch, Cast-Iron Gear	Position of Stressed Teeth and Equivalent Breaking Load									
	Single Tooth Loaded						2-Teeth Loaded		3-[?] Teeth Loaded	
										
	Test No.	*W*	Test No.	*W*	Test No.	*W*	Test No.	*W*	Test No.	*W*
20-*T*	4	1216	12	1440	1	1632	7	2112	9	1600
	5	1184	13	1476	2	1696	8	2176	10	1472
	6	1152	..	....	3	1664	..	....	11	1632
	Aver.	1184	Aver.	1458	Aver.	1664	Aver.	2144	Aver.	1568
30-*T*	18	1472	25	1877	14	1941	20	2603	23	1835
	19	1429	26	1707	15-16	Void	21	2176	24	1856
	..	....	27	1728	17	1899	22	2965	..	....
	Aver.	1451	Aver.	1771	Aver.	1920	Aver.	2581	Aver.	1846
40-*T*	31	Void	39	2416	28	2416	34	3360	36	Void
	32	1616	40	2336	29	2272	35	3360	37	2560
	33	1600	..	....	30	2208	..	....	38	2528
	Aver.	1608	Aver.	2376	Aver.	2299	Aver.	3360	Aver.	2544

TABLE 9 EQUIVALENT BREAKING LOADS

Size of Gear	20 T	30 T	40 T
W by Test, Position *A*	1184	1451	1608
W computed by Lewis Formula	1170	1317	1392

29 The test values of *W*, as given in Table 9, correspond to a formula for this position of engagement and static conditions:

$$W = \text{spf}\ (0.154 - \frac{1.26}{n})$$

The derivation of this formula from the experimental results will be found in Appendix No. 4. This equation would make the static strength of single teeth vary from that of a theoretically correct rack tooth down to a 20-tooth pinion in the ratio of 0.154 to 0.091; in other words, the rack tooth would have 1.69 times the strength of the 20-tooth pinion. The Lewis formula would give a ratio of 0.124 to 0.090 for the same gears. The discrepancy can be explained by the fact that the theory of flexure is recognized as only approximately correct, particularly for oblique forces, material which has not the same strength in tension as in compression, and for stresses beyond the elastic limit. Furthermore the Lewis factors neglect entirely the effect of the angularity of the force in producing a compressive stress. In the case of the 20-tooth gear this angularity is such as to make the compressive component of the acting force more than 50 per cent of the transverse component. The theory of flexure upon which the Lewis formula is based would have the fracture occur on a plane section (as shown in Fig. 7) and would have the breaking loads vary, approximately as the square of the thickness of the tooth at this section. As a matter of fact the fracture of the teeth in every case took place lower down on the root than at the points of tangency of parabolas inscribed on the Lewis assumption. The fractures took place rather at the points of tangency of parabolas constructed for loads applied at the pitch points as shown in Fig. 8, and the breaking loads varied more nearly in proportion to the squares of the thickness at this section. The surface of the break invariably was in the form of a curve running down into the root as shown and in no case did a tooth break square across.

30 Mention is made in Par. 26 of the necessity of taking the arc of action into consideration in dealing with the load-carrying strength of gear teeth. It would seem that the breaking load of a gear would depend not solely upon itself but also upon the gear with which it meshed. The larger the meshing gear, the greater the arc of action; and the greater the arc of action, the more likely the load is to be borne on two or more pairs of teeth simultaneously and the less likely that the entire load will fall on a single tooth in its position of least strength. It is desirable to see, then, what effect, if any, the length of arc of action has on the breaking load. To see what the effect was under static (zero pitch velocity) conditions a series of tests (Series 5) was conducted. Tests were made of 30-tooth gears in mesh with 30, 40, 60 and 80 tooth gears. It was found in making these tests that the position of the teeth in engagement made a vast difference in results. It was therefore necessary to find by trial the position of engagement corresponding to the least carrying power of the tooth. The results are given in Table 10. There is nothing to account for the foregoing variation in strength except the differences in arc of action. It was the intention to carry similar tests out on 30-tooth meshing with 80-tooth and 100-tooth, but it was found in trying the 30 and 80 pair,

TABLE 10 STATIC STRENGTH. SERIES 5, SEPTEMBER 26–27, 1912

Breaking Loads W of 30T in mesh with								
30T			40T			60T		
Series	Test	W	Series	Test	W	Series	Test	W
4	23	1835	5	1	2480	5	14	2453
4	24	1856	5	6	2368	5	15	2453
5	17	2475	5	7	2080			
5	18	2304	5	8	2112			
Average.............2118 Arc of Action, In...0.61158			Average.............2260 Arc of Action, In...0.62814			Average...........2453 Arc of Action, In...0.64919		

that the rim of the 80-tooth broke, cracking the arms and hub, before a breaking load of the teeth could be reached. Fig. 9, Curve *A*, shows the results of these tests, the ordinates being equivalent breaking loads at pitch point, and the abscissae being arcs of contact. There being no unbroken 20-tooth gears to use in Series 5, the value for static strength of 30-tooth meshing with 20-teeth (arc of action, 0.53938 in.) is taken from Fig. 4 Curve *A*.

31 From Table 9 it is seen that the static strength of a single tooth of a 30-tooth gear in its weakest position = 1451 lb. This would measure the strength of teeth with an arc of action of 0.314 in. or less, i.e. when the $\frac{\text{arc of action}}{\text{pitch arc}} \underset{<}{\pm} 1$. From Fig. 9, Curve *A*, for a 30-tooth meshing with a 20-tooth the arc of action equals 0.53938 in. and the corresponding $W = 1660$ lb. From these facts and Table 10 it is possible to construct Table 11 to show the relationship, under static conditions, existing between length of arc of action and equivalent breaking load.

TABLE 11 RELATION BETWEEN ARC OF ACTION AND EQUIVALENT STATIC LOAD

Ratio $\frac{\text{Arc of Action}}{\text{Pitch Arc......}}$	$\frac{0.31416}{0.31416}=1$	$\frac{0.53938}{0.31416}=1.72$	$\frac{0.61158}{0.31416}=1.95$	$\frac{0.62814}{0.31416}=2$	$\frac{0.64919}{0.31416}=2.07$
Breaking Load.......	1451	1660	2118	2260	2453
Ratio $\frac{\text{Breaking Load}}{1451}$	1	1.14	1.46	1.56	1.69

The range in breaking strength due to varying arcs of action, from 1 to 1.69 shown by this table, is as great as that due to *form* between 20 teeth and 150 teeth (see Par. 28); and it is greater than that due to variations in velocity from zero pitch speed to over 500 ft. per min. (see Par. 21). If form of tooth and velocity are of sufficient importance to be taken into account in a formula for gear tooth strength it is demonstrated that there should also be introduced a factor for arc of action.

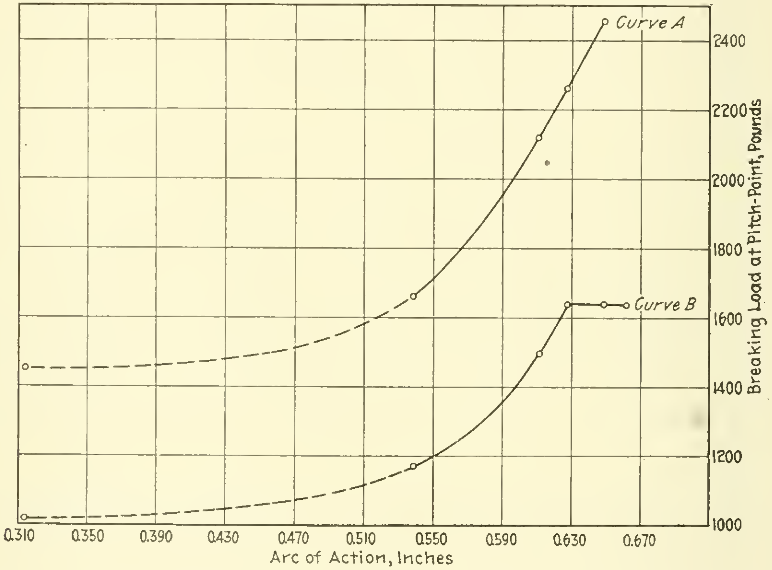


FIG. 9 RELATION BETWEEN EQUIVALENT BREAKING LOAD AND ARC OF CONTACT

32 Further light is thrown upon the extent of the influence of the length of arc of action if from Series 1 and 2 the tests involving 30 tooth gears made at nearly a uniform pitch velocity are selected. The following table gives the results of such tests made at about 290 ft. pitch velocity. Such a selection makes the arc of action the only variable factor. The values of Table 12 are shown graphically in Fig. 9, Curve *B*. There are no running experiments involving an arc of action of 0.31416. But from Figs. 4 and 5 it is clear that the breaking strength at 300 ft. per min. is about 70 per cent of the static strength. It is therefore not improper to assume that the break-

TABLE 12 RELATION BETWEEN ARC OF CONTACT AND BREAKING LOAD

Run	Speed	Gears	Arc of Contact	Breaking Load
6	290.03	30–20	0.53938	1280
7	310.55	30–20	0.53938	1109
15	322.01	30–20	0.53938	1109
16	318.87	30–20	0.53938	1152
17	322.01	30–20	0.53938	1195
				Average....1169
42	290.39	30–30	0.61158	1536
43	290.39	30–30	0.61158	1493
44	290.39	30–30	0.61158	1451
				Average.....1493
24	290.39	30–40	0.62814	1632
25	290.39	30–40	0.62814	1632
26	290.39	30–40	0.62814	1648
				Average....1637
35	290.38	30–60	0.64919	1643
36	290.38	30–60	0.64919	1664
37	290.38	30–60	0.64919	1600
				Average....1636
38	286.35	30–80	0.66209	1616[1]
39	292.40	30–80	0.66209	1632
40	290.39	30–80	0.66209	1648[1]
				Average....1632

[1] Data indicate that these values were lower than real strength of teeth. See Table 3.

ing strength for an arc of contract of 0.31416, at a pitch velocity of 300 ft. per min. would be 70 per cent of 1451 lb., or 1016 lb. On this assumption and the data of Table 11, Table 13 has been computed.

It is interesting to note how closely this agrees with Table 9.

33 The results in Tables 11 and 13 may now be combined and a table of coefficients a constructed by which the effect of the arc of action may be introduced into the formula for the strength.

TABLE 13 RELATION BETWEEN ARC OF ACTION AND BREAKING LOAD UNDER RUNNING CONDITIONS

Ratio: $\frac{\text{Arc of Action}}{\text{Pitch Arc}}$	$\frac{0.31416}{0.31416}=1$	$\frac{0.53935}{0.31416}=1.72$	$\frac{0.61158}{0.31416}=1.95$	$\frac{0.62814}{0.31416}=2$	$\frac{0.64919}{0.31416}=2.07$	$\frac{0.66209}{0.31416}=2.11$
Breaking Load	1016	1169	1493	1637	1636	1632
Ratio: $\frac{\text{Breaking Load}}{1016}$	1	1.15	1.47	1.61	1.61	1.61

TABLE 14 COEFFICIENTS BASED ON ARC OF ACTION

Ratio: $\frac{\text{Arc of Action}}{\text{Pitch Arc}}$	1	1.4	1.6	1.7	1.8	1.9	1.95	2.00
Corresponding a	1	1.05	1.1	1.15	1.24	1.38	1.47	1.60

34 The entire formula as derived from these experiments for the safe equivalent load at pitch line may now be written

$$W=\frac{spf}{k}\left(0.154-\frac{1.26}{n}\right)va.$$

in which

W = safe working load at pitch line in pounds
s = modulus of rupture = 39,000 in these tests but ordinarily to be taken = 36,000.
p = circular pitch in inches
f = width of face in inches
k = factor of safety
n = number of teeth in gear
v = velocity coefficient from Table 6.
a = arc of action coefficient from Table 14.

35 The general effect of arcs of action and of pitch speed on the breaking strength of gear teeth as found in these experiments can best be seen by combining Fig. 4, Curve A, Fig. 5 and

Fig. 9, Curves *A* and *B* into a single isometric chart. This is done in Fig. 10. The ordinates, as heretofore, represent equivalent breaking loads at pitch point in pounds. One set of abscissae represents pitch speeds in feet per minute; the other set represents lengths of arc of action in inches.

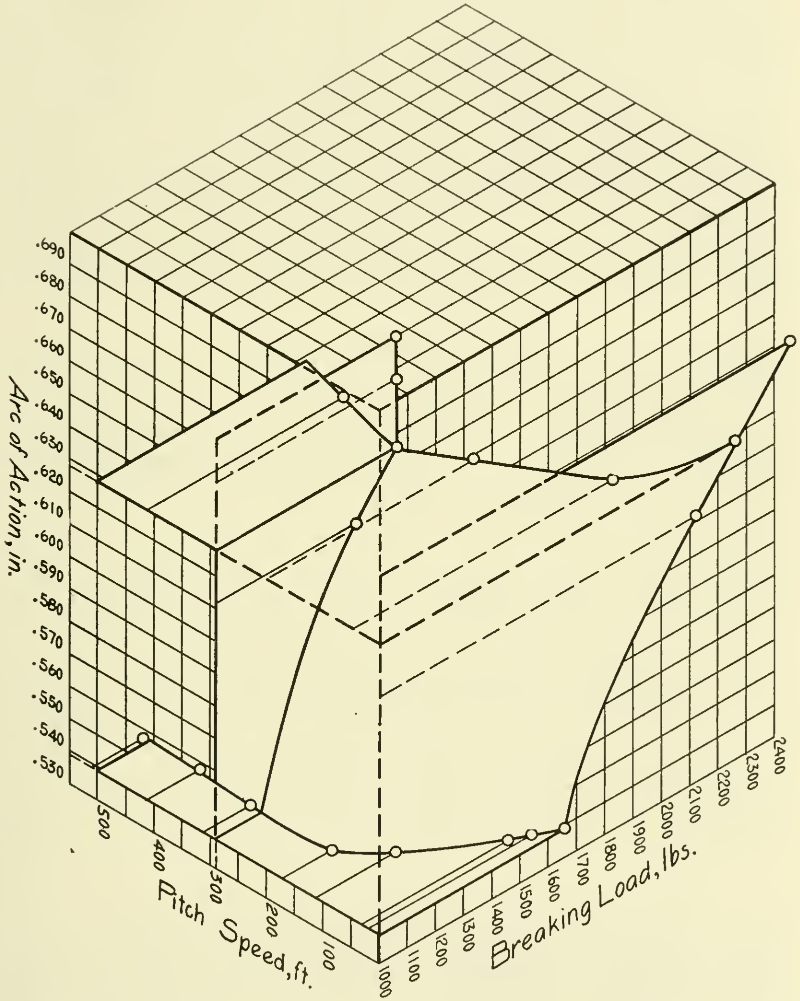


Fig. 10 Relations Between Arc of Action, Pitch Speed and Breaking Load Shown Isometrically

36 To complete the record of this experimentation mention should be made of the tests which were designated as Series 3. In planning these it was thought that the remaining unbroken gears could have their width of face turned down to one-half its previous value, and then, the teeth being theoretically just half as strong as those of the full-width gears, tests might be conducted at higher pitch speeds and the gears ruptured within the capacity of the motor. The observed breaking load could then be doubled as the breaking load of the full-width gears and points so obtained be used to extend the curve of direct observations. The results of a very few tests proved that this could not be done. The data and results are briefly tabulated in Table 15.

TABLE 15 SERIES 3, JULY 1, 1912

Test No.	Width of Face	Change Gears		Test Gears		Motor R.P.M.	Net Brake Load, Lb.	PitchSpeed Brake Gear Ft.perMin.	Equivalent Load at Teeth, Lb.
		Sprocket	Intermediate	Intermediate	Brake				
48	17/32	70	40	30	30	720	28	508.18	597
49	1 1/16	70	40	30	30	720	66	508.18	1408
50	17/32	40	20	30	30	720	28	580.77	597
51	1 1/16	40	20	30	30	720	62	580.77	Could not break. Circuit-Breaker out.
52	1 1/16	70	40	30	30	720	66	508.18	1408 Same Gears as Test 51

It is evident from Tests 48-49 and 50-51 that the half width teeth have not one-half the strength of the full-width teeth. Only speculations can be offered as to this apparent discrepancy. It may be that the wider teeth forced better alignment conditions without unduly stressing the teeth. Or it may be that the additional mass plays some part in shock absorption. But, since observations could not be used to supplement those on full-width gears no further runs were made.

37 It would appear that the factors of safety in common use,

in so far as breaking strength of the teeth is concerned, while they might properly serve for rough cast gears, are much too large for modern, accurately cut gears; and that Mr. Lewis and Mr. Christie were quite right in assuming that the factor of safety at any speed need not be more than double that which will suffice for the slowest speed.

38 A few words may be added about the general design of the gears. The almost invariable breaking of the 20-tooth gears, 1 1/16 in. bore, ¼ in. keyway, tends to indicate that this is just about the maximum limit of bore which can be used with these gears while getting the maximum out of the tooth strength. Any larger bore, it seems, would simply allow these gears to split at the keyway without stripping any teeth. Of the 30- and 40-tooth gears, and of the proportions of the 60-tooth there can be no criticism. In all cases the failure came at the teeth, although it is indicated that the 60-tooth gears could have borne heavier loads if they had been solid. As a whole the tests involving gears with more than 60 teeth were indecisive so far as throwing any light on the strength of the teeth was concerned. These gears were not solid nor webbed but had arms, and their less rigid design allowed them to yield and fracture at rim, arms and hub before the breaking strength of the teeth could be reached. To bring the rest of the gear up to the strength of the teeth would seem to require a larger diameter of hub, thicker rims and heavier arms. In loading the gears up to the breaking strength of the teeth considerable difficulty was encountered with shearing and battering of keys. This was practically overcome by the use of hardened tool-steel keys. A photographic log follows which shows the manner in which the gears failed.

ACKNOWLEDGMENT

The writer wishes to acknowledge his appreciation of the many kindnesses of his colleagues and the laboratory assistants. Particular thanks are due to Mr. L. E. Cutter, instructor in mechanical engineering, without whose unfailing assistance the tests could scarcely have been completed. All observations were made by the writer and Mr. Cutter personally.

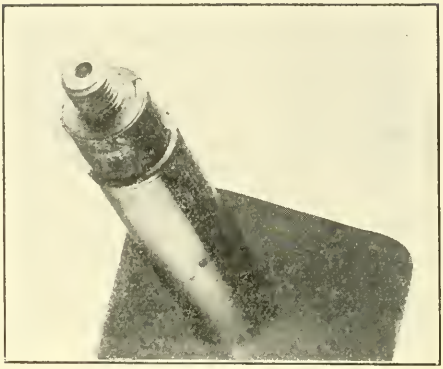


FIG. 11 KEY SHEARED IN TEST 01, SERIES 1

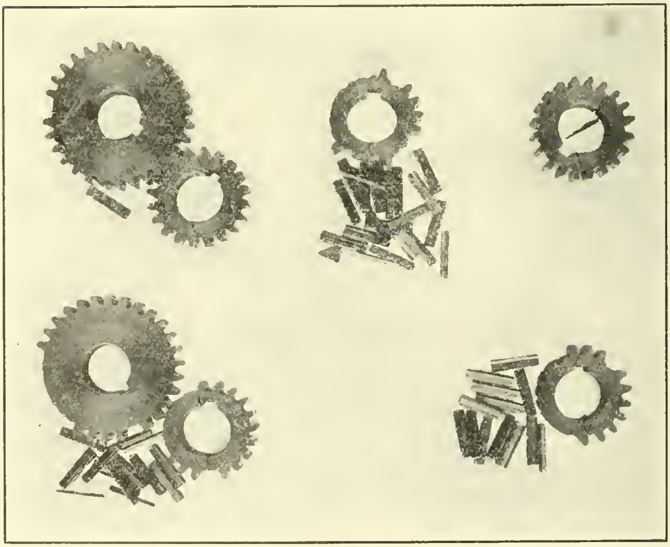


FIG. 12 20 TOOTH ENGAGING 30 TOOTH, TESTS 04—08 INCLUSIVE, SERIES 1

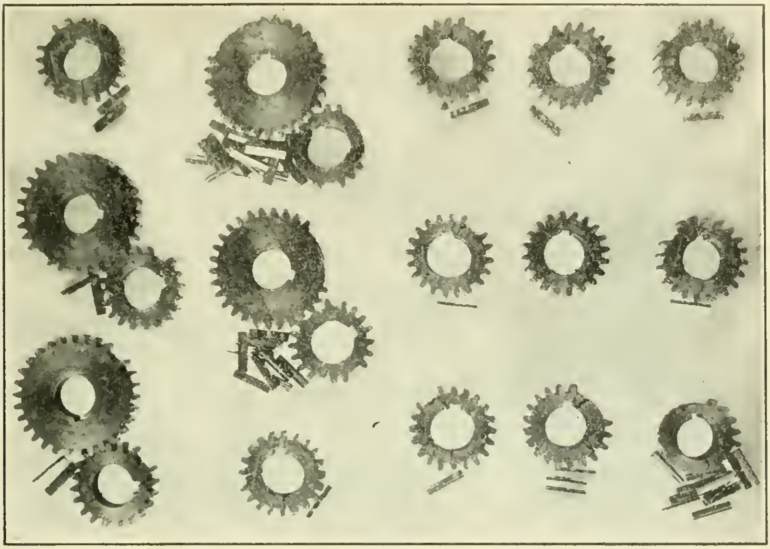


Fig. 13 20 Tooth engaging 30 Tooth, Tests 1—17 inclusive, Series 2

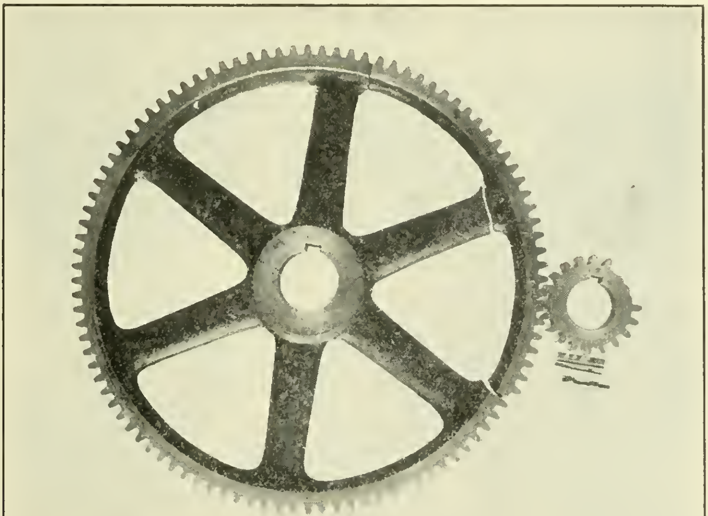


Fig. 14 20 Tooth engaging 100 Tooth, Test 03, Series 1

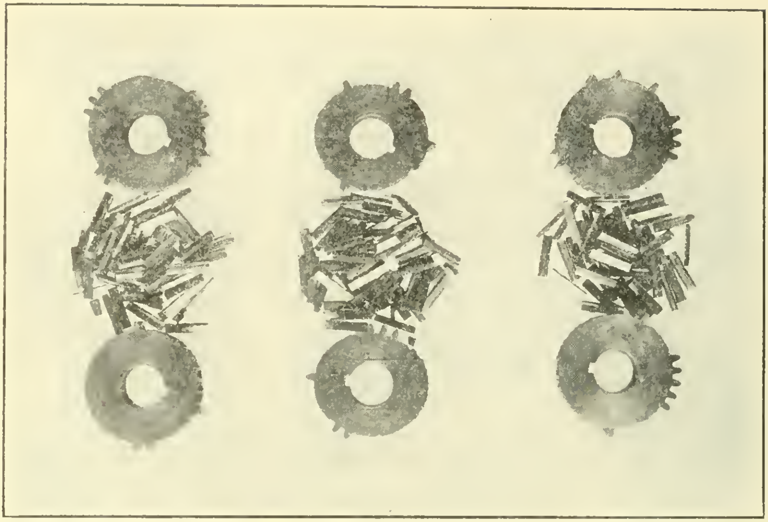


FIG. 15 30 TOOTH ENGAGING 30 TOOTH, TESTS 42—44 INCLUSIVE, SERIES 2

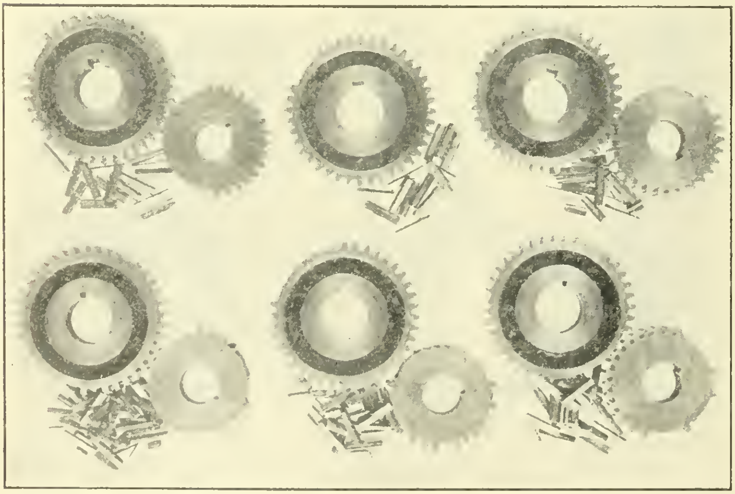


FIG. 16 30 TOOTH ENGAGING 40 TOOTH, TESTS 18—23 INCLUSIVE, SERIES 2

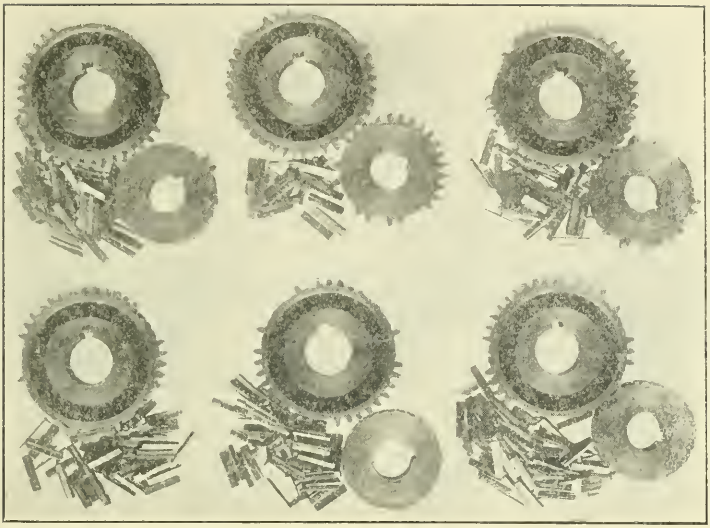


FIG. 17 30 TOOTH ENGAGING 40 TOOTH, TESTS 24—26, 32—34 INCLUSIVE, SERIES 2

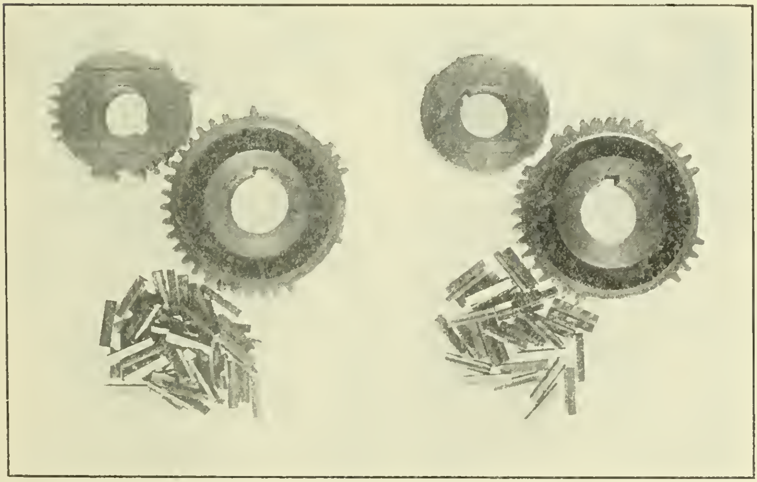


FIG. 18 30 TOOTH ENGAGING 40 TOOTH, TEST 09, SERIES 1 AND TEST 28, SERIES 2

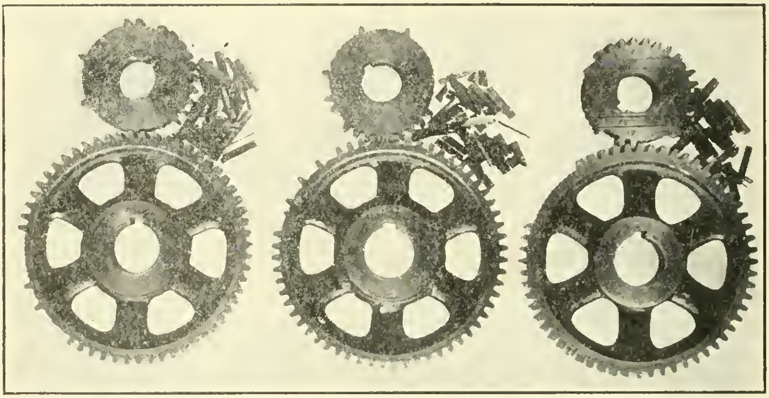


Fig. 19 30 Tooth engaging 60 Tooth, Tests 35—37 inclusive, Series 2

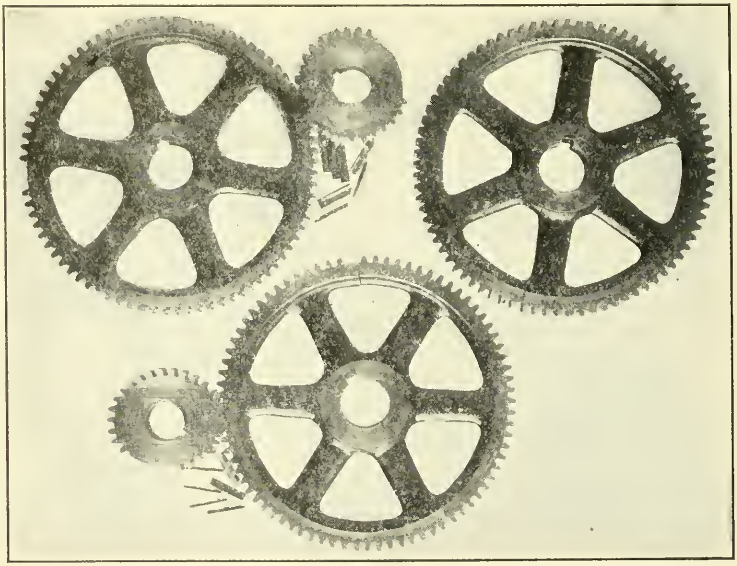


Fig. 20 30 Tooth engaging 80 Tooth, Tests 38—40 inclusive, Series 2

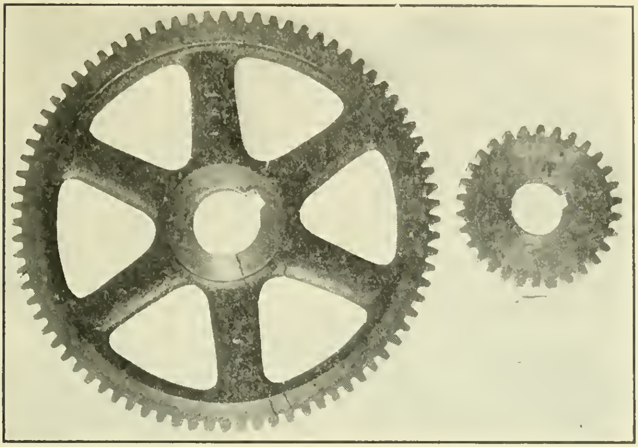


Fig. 21 30 Tooth engaging 80 Tooth, Test 45, Series 2. German Hexagonal Key used in 80 Tooth

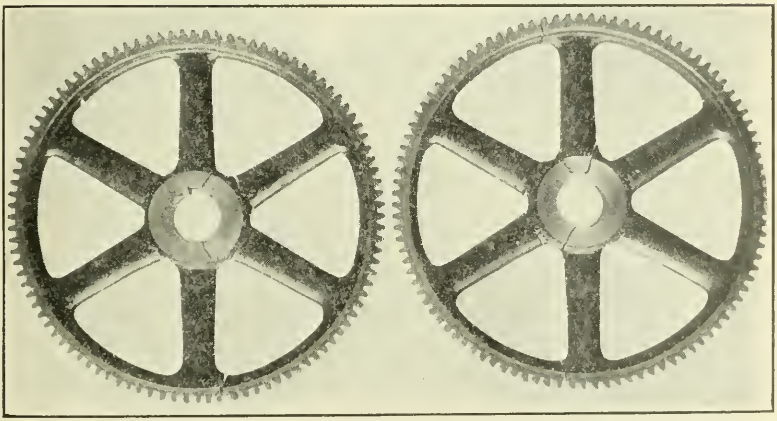


Fig. 22 30 Tooth engaging 100 Tooth, Tests 41 and 46, Series 2

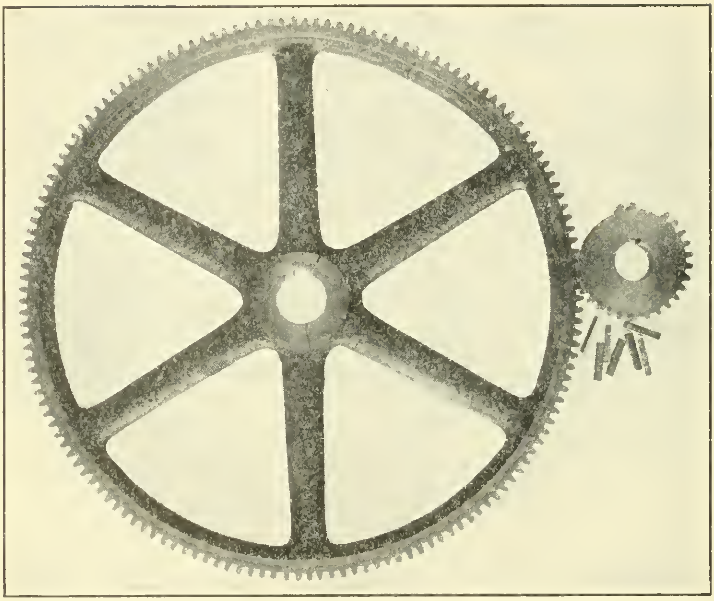


FIG. 23 30 TOOTH ENGAGING 150 TOOTH, TEST 016, SERIES 1

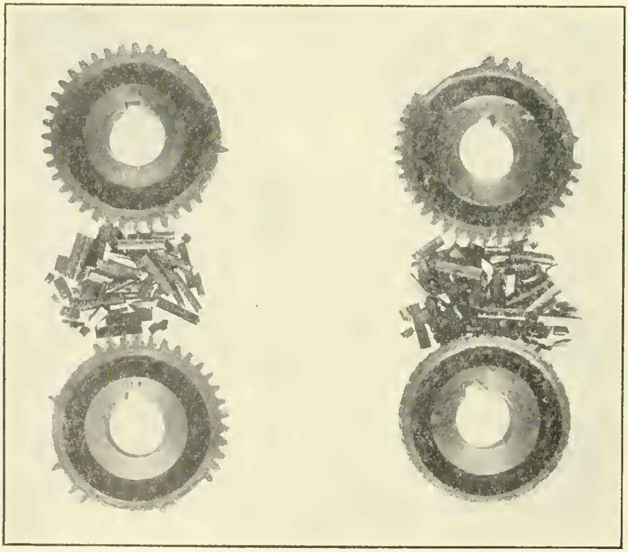


FIG. 24 40 TOOTH ENGAGING 40 TOOTH, TEST 011, SERIES 1 AND 47, SERIES 2

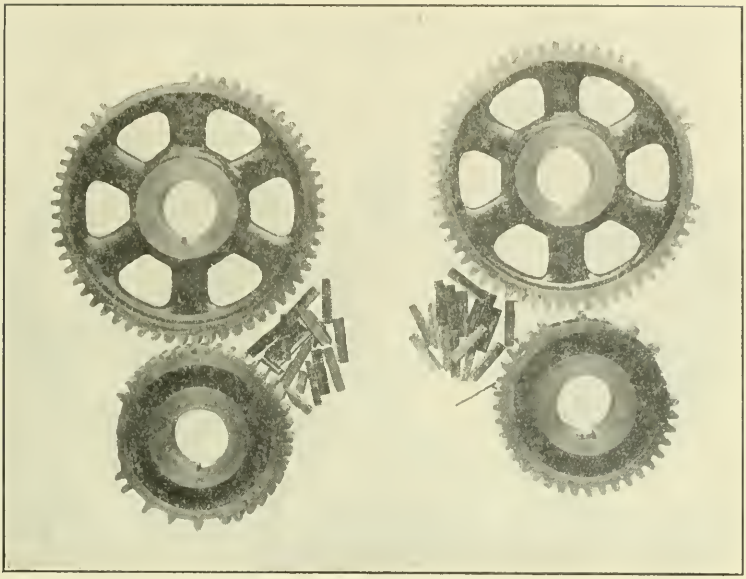


Fig. 25 40 Tooth engaging 60 Tooth, Tests 010 and 012, Series 1

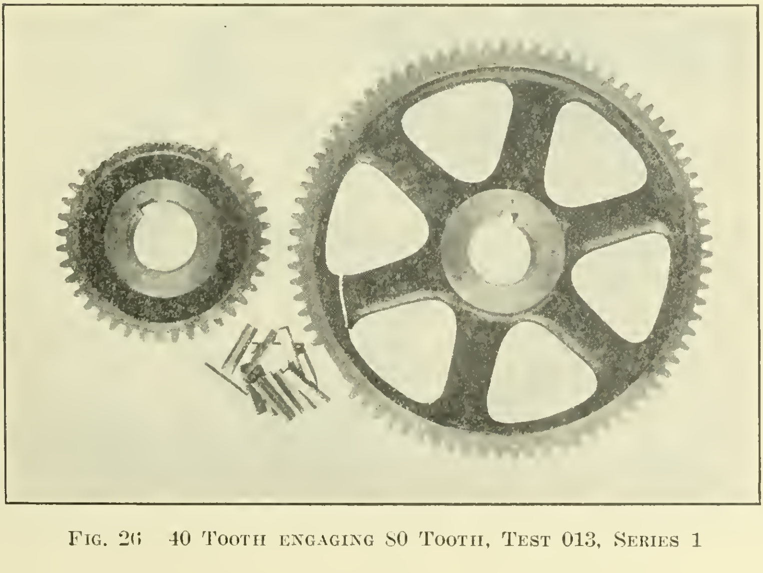


Fig. 26 40 Tooth engaging 80 Tooth, Test 013, Series 1

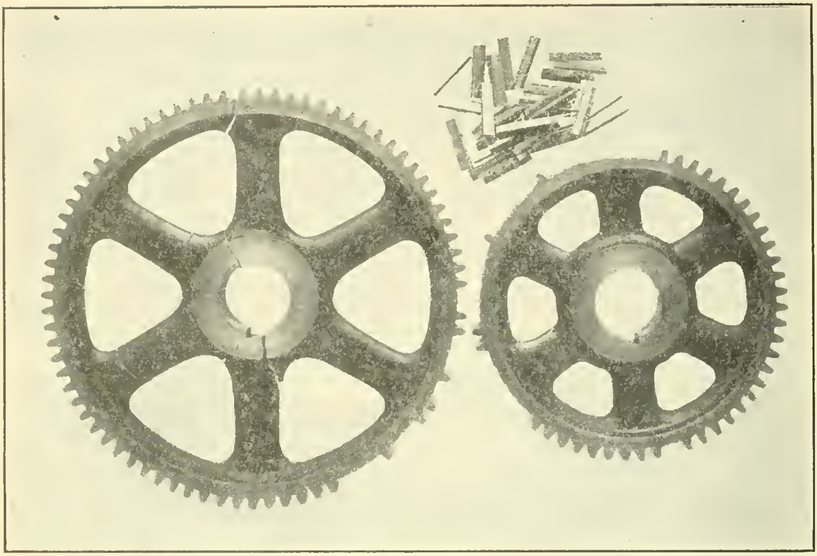


FIG. 27 60 TOOTH ENGAGING 80 TOOTH, TEST 014, SERIES 1

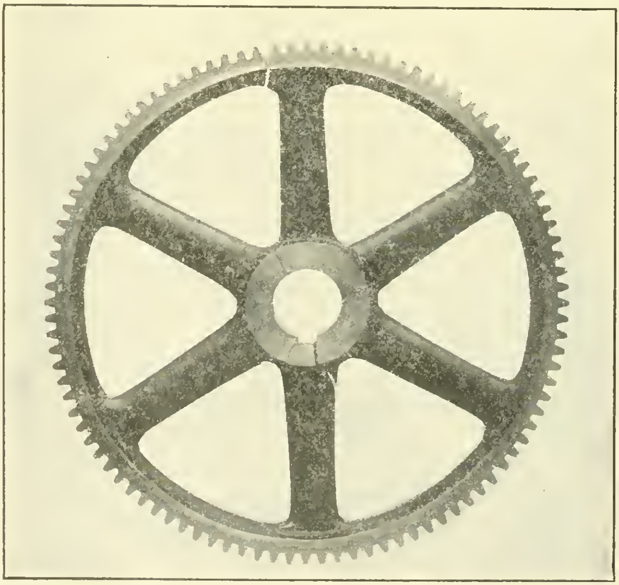


FIG. 28 80 TOOTH ENGAGING 100 TOOTH, TEST 015, SERIES 1. 80 TOOTH INTACT

APPENDIX NO. 1

POINTS FOR FIG. 4, CURVE *B*

By Lewis formula

$$W = spf\left(0.124 - \frac{0.684}{n}\right)$$

$s = 8000$ for 0 to 100 ft. per min.

$W = 8000 \times 0.31416 \times 1.0625 \times 0.90 = 240$ ....[1]

$s = 4800$ for 300 ft. per min.

$W = 4800 \times 0.31416 \times 1.0625 \times 0.90 = 144$ ....[2]

$s = 4000$ for 600 ft. per min.

$W = 4000 \times 0.31416 \times 1.0625 \times 0.90 = 120$ ....[3]

APPENDIX NO. 2

39 To see how closely the factor of strength y obtained by the Lewis formula

$$y = 0.124 - \frac{0.684}{n},$$

corresponded to the forms of teeth used in this system, the following investigations were made:

40 The teeth were measured as accurately as possible, laid out 100 times full size, parabolas inscribed as shown in Figs. 7 and 8, and the distances from vertices to pitch point, and from tangent lines to pitch point, measured. The results are given in Table 16.

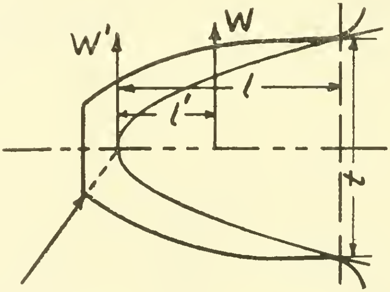


FIG. 29 SHOWING ASSUMED POINT OF APPLICATION OF FORCE AND RESISTANCE OF TOOTH

41 Referring to Fig. 29, the load is assumed to be applied at the end of the tooth and normal to the profile. The transverse component $= W'$, and the equivalent force at the pitch line $= W$. The thickness of tooth at point of tangency of the inscribed parabola $= t$. The distance from the pitch line to vortex of parabola $= l'$, and from the vortex to the tangent line $= l$.

s = modulus of rupture

f = width of face in inches

$\frac{I}{c}$ = modulus of section

r = pitch radius of gear

Then, from the theory of flexure,

$$W' l = \frac{s I}{c} = \frac{s f t^2}{6} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [4]$$

TABLE 16 DIMENSIONS OF GEAR TEETH

No. of Teeth	Thickness at Depth							End Load Parabola			Pitch Load Parabola		
	0.00	0.048	0.100	0.150	0.175	0.185	0.200	Thicknes at Tangency	Tangent Line to Pitch Line	Vertex to Pitch Line	Thickness at Tangency	Vertex to Pitch Line	Tangent Line to Pitch Line
20	0.070	0.1240	0.1570	0.1630	0.1630	0.1630	0.1680	0.1662	0.0964	0.0760	0.1680	0.0152	0.1002
30	0.080	0.1277	0.1572	0.1678	0.1701	0.1710	0.1760	0.1750	0.0975	0.0740	0.1784	0.0150	0.1014
40	0.086	0.1260	0.1570	0.1730	0.1760	0.1785	0.1830	0.1820	0.0964	0.0797	0.1860	0.0160	0.1013
60	0.092	0.1300	0.1570	0.1745	0.1800	0.1840	0.1910	0.1896	0.0972	0.0800	0.1918	0.0158	0.1002
80	0.086	0.1260	0.1550	0.1760	0.1815	0.1850	0.1910	0.1902	0.0976	0.0789	0.1922	0.0178	0.1005
100	0.088	0.1240	0.1550	0.1750	0.1820	0.1870	0.1950	0.1920	0.0946	0.0815	0.1966	0.0178	0.1015
150	0.096	0.1300	0.1570	0.1800	0.1900	0.1930	0.2000	0.1980	0.0968	0.0815	0.2020	0.0191	0.1020
Rack	0.1053	....	0.1570	....	....	....	0.2094	0.2080	0.0983	0.0864	0.2126	0.202	0.1028

TABLE 17 COMPARISON OF VALUES OF Y

Size of Gear	$\frac{k}{6p}$	$\frac{\text{Table 1}}{\text{Lewis}}$	$0.124 - \frac{0.684}{n}$
20T	0.0914	0.090	0.0898
30T	0.0995	0.102	0.1012
40T	0.1038	.....	0.1069
60T	0.1105	0.114	0.1126
80T	0.1109	.....	0.1154
100T	0.1128	0.118	0.1172
150T	0.1180	0.120	0.1194

$$W' = \frac{sft^2}{6l} \quad\text{..........} [5]$$

Also, by moments about center of gear.

$$W'(r+l') = Wr \quad\text{..........} [6]$$

$$W' = W\frac{r}{r+l'} \quad\text{..........} [7]$$

Substituting value of W' from [7] in [5].

$$W\frac{r}{r+l'} = \frac{sft^2}{6l} \quad\text{..........} [8]$$

$$W = \frac{sf}{6}\cdot\frac{t^2}{l}\cdot\frac{r+l'}{r} \quad\text{..........} [9]$$

Say,

$$W = \frac{sf}{6}\cdot k \quad\text{..........} [10]$$

where

$$k = \frac{t^2}{l}\cdot\frac{r+l'}{r} \quad\text{..........} [11]$$

By Lewis formula.

$$W = spfy$$

Hence,

$$spfy = \frac{sf}{6}\cdot k$$

$$y = \frac{k}{6p} \quad\text{..........} [12]$$

42 To find the factors y corresponding to the gear teeth of these tests, computations were made using the actual dimensions as given in Table 16. The results are formulated in Table 17, together with the values of y given in Table 1 of Lewis's original paper, and as computed from his formula

$$y = 0.124 - \frac{0.684}{n}$$

for 15 deg. involute, given in the American Machinist, June 22, 1893.

43 No single expression of the form $x = \frac{y}{n}$ can satisfy all of these values of $\frac{k}{6p}$. They call for a range from $0.124 - \frac{0.652}{n}$ to $0.124 - \frac{1.120}{n}$ but the expression $0.124 - \frac{0.684}{n}$ gives values for the factor of safety which do not vary by as much as 5 per cent in any case from the values determined from the actual tooth dimensions.

APPENDIX NO. 3

DETERMINATION OF ARC OF ACTION

44 The tooth comes into contact, neglecting for the present those cases of gears with such a small number of teeth that there would be interference, when the addendum circle of the driven gear cuts the line of action. This position of the tooth is shown at c', Fig. 30.

45 Contact between this tooth and its mate will continue until the addendum circle of the driver cuts the line of action, again neglecting those cases involving interference. This position is shown at c. The length of the arc of action $d'd$ is important as it governs the number of pairs of teeth simultaneously in contact.

46 The position of the tooth for pitch-point contact is shown at a. The corresponding point of tangency of the line of action and the base circle is b. It is obvious that b'' bears this same relationship to d; and b''' to d'. Hence, when the driven gear tooth travels from position $c'd'$ to cd, which is its complete period of action, the base circle will have rotated through the arc $b'''b''$.

From the nature of the involute curve,

$$ab\ (= db'') = cb + \text{arc } bb''$$

Also

$$ab = ac + cb$$

Hence

$$ac = \text{arc } bb'' \qquad [13]$$

Similarly it can be shown that

$$ac' = \text{arc } bb''' \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [14]$$

Adding [13] and [14]

$$ac + ac' = \text{arc } b'' + \text{arc } b'''$$

Hence $cc' = \text{arc } b''\ b''' =$ length of line of actual action.

47 The cases involving interference may also be considered by reference to Fig. 30. If either gear has so few teeth that ab' becomes less than ac', the value of $b''\ b'''$ will, of course, equal $b'c$ (and not $c'c$). If both gears are low-numbered so that ab' is less than ac', and ab less than ac, the value of $b''\ b'''$ will equal $b'b$.

48 It is evident from Fig. 30 that the radius of base circle = the radius of pitch circle × cos 14½ deg. for the 14½ deg. involute system. Hence

Radius of pitch circle = radius of base circle × sec 14½ deg.

And

Arc of pitch circle corresponding to $b''\ b'''$ of base circle = $b''\ b'''$ sec 14½ deg. = length of arc of action.

49 The actual length of the line of action in any case may be readily computed.

50 Referring to Fig. 31, $0ac$ is a triangle in which

side $0a$ = pitch radius of driver r

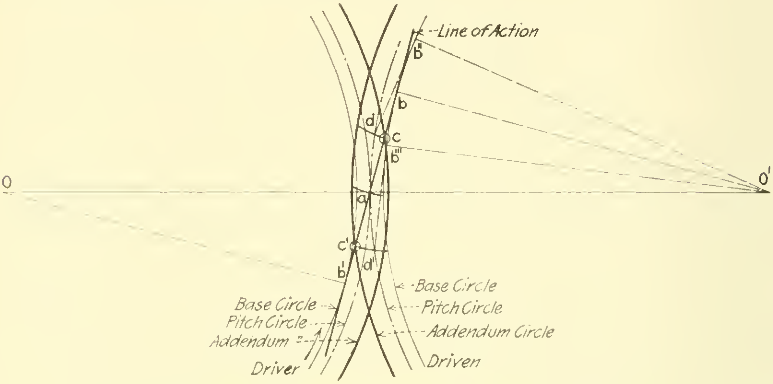


Fig. 30 Showing Point of Initial Contact of Teeth

side $0c$ = pitch radius of driver plus addendum $r + a$

angle $0ac$ = 90 deg. + 14 deg. 30 min. = 104 deg. 30 min.

$$\sin x = \sin 104 \text{ deg. } 30 \text{ min. } \frac{r}{r+a}$$

hence angle x becomes known.

$$\text{Angle } y = 180 \text{ deg.} - (104 \text{ deg. } 30 \text{ min.} + \text{angle } x)$$

$$ac = r\,\frac{\sin y}{\sin x}$$

Similarly ac' may be computed for the driven gear.

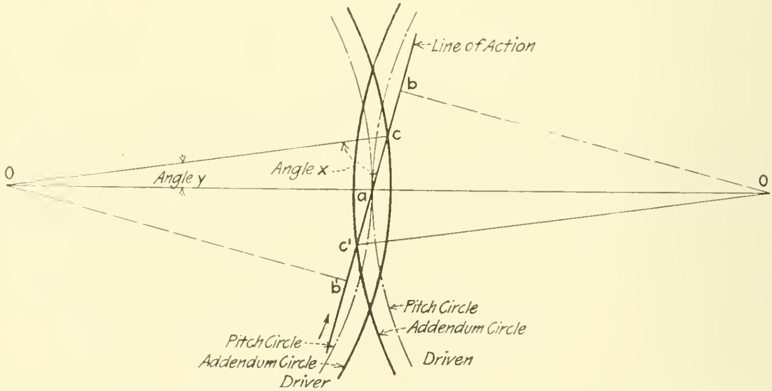


Fig. 31 Diagram to illustrate Length of Line of Action of Teeth

51 In cases involving interference it must be borne in mind that $ab' = 0a \sin 14\frac{1}{2}$ deg. and $ab = 0'a \sin 14\frac{1}{2}$.

TABLE 18-a COMBINATIONS OF 10-PITCH GEARS

Gear, No. Teeth	*ab*, Inches	*ac*, Inches
20	0.25038	0.27182
30	0.37557	0.29605
40	0.50076	0.31208
60	0.75114	0.33246
80	1.00152	0.34495
100	1.25190	0.35345
150	1.87775	0.36637

The 20 tooth is the only one in the set used in these experiments where *ab* is less than *ac*, i. e. where theoretical interference is involved.

TABLE 18-b COMBINATIONS OF 10-PITCH GEARS

Gear Teeth		Line of Contact, Inches	Arc of Contact, Inches
Driver	Driven		
20	30	0.52220	0.53938
20	100	0.52220	0.53938
20	150	0.52220	0.53938
30	30	0.59210	0.61158
30	40	0.60813	0.62814
30	60	0.62851	0.64919
30	80	0.64100	0.66209
30	100	0.64950	0.67087
30	150	0.66332	0.68514
40	40	0.62416	0.64469
40	60	0.64454	0.66575
40	80	0.65703	0.67866
60	80	0.67741	0.69970
80	100	0.69840	0.72138

In all these cases except those involving 20—Tooth gears the line of contact equals the sum of the respective *ac*'s. In cases involving the 20-Tooth gears it equals the *ab* of the 20-Tooth plus the *ac* of the 20-Tooth.

52 From the values of *ab*, *ab'*, *ac* and *ac'* so computed the length of the actual line of action in any given case becomes known. This gives the length of the corresponding arc $b'' b'''$ and multiplying this by sec $14\frac{1}{2}$ deg., the actual length of the arc of action is obtained.

53 Tables 18-a and 18-b give the results of such computations for the combinations of 10-pitch gears used in these tests.

APPENDIX NO. 4

DERIVATION OF FORMULA

$$W = spf\left(0.154 - \frac{1.26}{n}\right)$$

54 Assuming the Lewis form of expression

$$W = spf\left(x - \frac{y}{n}\right)$$

as the general formula in which the values of x and y are to be determined.

55 It is known that

$$s = 39000 \text{ in all cases}$$
$$p = 0.31416 \text{ in all cases}$$
$$f = 1.0625 \text{ in all cases}$$
$$W = 1184 \text{ when } n = 20$$
$$= 1451 \text{ when } n = 30$$
$$= 1608 \text{ when } n = 40$$
$$spf = 13018.$$

When $n = 20$

$$1184 = 13018\left(x - \frac{y}{20}\right) \ldots\ldots\ldots\ldots [15]$$

$$0.091 = \left(x - \frac{y}{20}\right) \ldots\ldots\ldots\ldots [15a]$$

$$1.82 = 20\ x - y \ldots\ldots\ldots\ldots [15b]$$

Similarly when $n = 30$

$$1451 = 13018\left(x - \frac{y}{30}\right) \ldots\ldots\ldots\ldots [16]$$

$$0.112 = x - \frac{y}{30} \ldots\ldots\ldots\ldots [16a]$$

$$3.36 = 30\ x - y \ldots\ldots\ldots\ldots [16b]$$

And, when $n = 40$

$$1608 = 13018\left(x - \frac{y}{30}\right) \ldots\ldots\ldots\ldots [17]$$

$$0.123 = x - \frac{y}{40} \ldots\ldots\ldots\ldots [17a]$$

Subtracting [15b] from [16b]

$$\begin{array}{rl} 30\ x - y & = 3.36 \\ 20\ x - y & = 1.82 \\ \hline 10\ x & = 1.54 \\ x & = 0.154 \end{array}$$

Substituting in [16*a*]

$$0.091 = 0.154 - \frac{y}{20}$$

$$\frac{y}{20} = 0.063$$

$$y = 1.26$$

Therefore

$$x - \frac{y}{n} = 0.154 - \frac{1.26}{n}$$

Check

$$0.154 - \frac{1.26}{20} = 0.091 \quad \text{when } n = 20$$

$$0.154 - \frac{1.26}{30} = 0.112 \quad \text{when } n = 30$$

$$0.154 - \frac{1.26}{40} = 0.1225 \text{ when } n = 40$$

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

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FOREIGN REVIEW

With this number the Foreign Review enters into its second year. The considerable number of inquiries received in connection with this new branch of the activities of the Society and the fact that several large firms having research departments have made special arrangements for handling the material published in the Foreign Review, shows that it is rendering a needed service.

THIS MONTH'S ARTICLES

Among this month's articles will be found two interesting communications on air machinery: tests of a turbo-compressor and of tunnel compressed air locomotives; the latter of particular interest owing to the scarcity of experimental data on the efficiency of this kind of apparatus due to the great inconvenience of testing under working conditions. Ventou-Duclaux's article on the use of naphthalene for internal combustion engines describes several types of French carbureters for use in this class of machinery, and gives data of tests. The naphthalene engine is of certain interest as being one of the cheapest in operation, and nearly the safest; its main disadvantage lies in the fact of its being very far from fool-proof. Heinz's article on peat utilization indicates that peat gas power is already the cheapest source of power in existence. Several new types of internal combustion engines are described, particular attention being here called to the Urbani two-stroke cycle engine.

In the Machine Shop section is given a description of a new crucible furnace, economical in fuel consumption and life of crucibles, as well as interesting data on the cost of heat treatment of metals by gas; an article by Buderus on the testing of molding sands is also of interest.

The article on the Kommer gear in the November issue of The Journal brought forth several inquiries for more information, in reply to which an abstract of the second part of the Kommer article is here given describing another type of the Kommer gear. Attention is also called to the article by Wolzogen Kühr on the design of centrifugal fans without using Euler's formulae.

In the section of Steam Engineering will be found several articles on the design of high capacity boilers, including the Glogner type, as well as La Maestra's article on the corrosion in boilers giving formulae for calculating the safe life of a boiler after some corrosion has started, as well as a table of what the author calls "time coefficients for corrosion in boilers." New processes for determining the heat conductivity in plate shaped bodies are given, of higher reliability than the methods previously used.

The section Miscellanea covers such articles as are of interest to the American mechanical engineer, but cannot through lack of space, be given a regular section in the Foreign Review. Among this month's abstracts will be found several articles in connection with farm machinery, automatic fire protective apparatus, as well as a number of smaller abstracts.

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Aeronautics

AUTOMATIC RESTORATION OF EQUILIBRIUM OF FLYING MACHINES (*Zur selbsttätigen Bekampfung von Gleichgewichtsstörungen bei Flugzeugen,* z.D.K.N. *Prometheus*, vol. 24, no. 1204, p. 116, November 23, 1912. 2 pp. *t*). The author, evidently connected in some way with the German military aviation corps, recommends a system of *automatic stabilization* based on the following principles: (*a*) separation of the airship into two rigidly connected parts, one comprising the carrying and guiding planes, "planes-body," and the other the usual heavy parts, "weight-body"; (*b*) spring joint connection between the two, such that when an external action produces change in the mutual position of the two component parts, this change itself is used to set into action the apparatus used for restoring the original state; (*c*) arrangements for cutting out the automatic stabilizing arrangement when required, e.g. in landing; (*d*) independence of the individual steering devices from those providing automatic stabilization. The author attempts to prove that the separation of the airship into two parts, "weight-body" and "planes-body" would contribute to an easier installation of automatic stabilizing devices. The arrangement proposed has never been tried.

A Speed Formula Applicable to Aeroplanes (*Sur une formule de vitesse applicable aux aéroplanes*, A. Berget. *Comptes rendus des séances de l'Académie des Sciences*, vol. 155, no. 20, p. 963, November 11, 1912. 2 pp. *cA*). The author derived the following experimental formula for the determination of the speed of an aeroplane:

$$V = A\sqrt[3]{\frac{F}{S}}$$

where V is the speed of the aeroplane in myriameters (1 myriameter = 6.2137 miles) per hour, S the supporting surface in sq. m., F power of the motor in h.p. (continental h.p. equals 736/746 of American h.p.), while A is a numerical coefficient whose value lies between 7 and 8. The value of A has been established experimentally, as well as the formula itself, from an investigation of a number of aeroplanes of various systems, and takes care of the elements of aeroplane design not otherwise considered in this formula. The best results are obtained when the value of A is 8 or very close to 8, but it must not be accepted from this that if an aeroplane has A equal to 7 or but slightly in excess of 7, it is unsatisfactory: that may simply mean that it has not been designed for speed, or that speed has been considered of secondary importance as compared with safety and strength of construction. A table of data for various French aeroplane types is given in the article showing that in all cases A lies practically between 7 and 8.

Air Machinery

Tests of a Turbo-Compressor at the Westerholt Mine. (*Untersuchung eines Turborcompressors auf der Zeche Westerholt. Glückauf*, vol. 48, no. 47, p. 1913, November 23, 1912. 3 pp., 2 figs. *de*). Description and data of *tests of an air compressor plant* at the Westerholt mine, Ruhr district, Prussia, from a communication of the Essen office of the Association for the Inspection of Steam Boilers. The turbine driving the compressor is so arranged as to be able to work both with live and exhaust steam, while the compressor can take in either 10000 cbm (say 35000 cu. ft.) of air per hour and compress it to 6 atmospheres, itself running at 4400 r.p.m., or it can run at 4200 r.p.m., and compress to 5.5 atmospheres 5000 cbm of outside air. The consumption of steam was guaranteed to be: for exhaust steam only, when handling 10000 cbm, 1.4 kg/cbm (say 0.04 lb. per cu. ft.), for 5000 cbm, 1.78 kg/cbm (say 0.051 lb. per cu. ft.); for live steam only 0.69 kg/cbm and 0.88 (say 0.02 and 0.025 lb. per cu. ft.) for the full and half load respectively. The actual test values are slightly more favorable than these. The article contains full data of the test.

Tests of Tunnel Compressed Air Locomotives (*Untersuchungen an Tunnel-Druckluftlokomotiven*, V. Litz. *Glückauf*, vol. 48, no. 45, p. 1825, November 9, 1912. 7 pp., 4 figs. *cA*). For the construction of the Mont d'Or tunnel the A. Borsig works, of Berlin-Tegel, Germany, have delivered two types of compressed air locomotives, three-axle of 11 tons in working order, and four-axle of 31 tons weight, both with double preheating of air done in the following manner: The air after coming from the pressure reducing valve between the compressed air tanks on the locomotive and the high-pressure cylinder passes through a special set of heater pipes, and again through a second set of similar pipes in passing from the high-pressure to the low-pressure cylinder. The furnace for heating the pipes is on the locomotive frame, a small stack being provided in the front part of the locomotive to take care of the gases of combustion. Coal and charcoal are used for fuel in order to obtain a practically smokeless combustion. The preheating is such as to raise the temperature of the air in both cylinders to about 180 deg. cent. (356 deg. fahr.). With a grade of 0.13 per cent, the larger locomotives can haul up to 180 tons, and the smaller up to 55 tons gross (in all cases a metric ton of 2200 lb. is meant). Fig. 1 shows the general arrangement of the locomotive.

The data are interesting particularly on account of the scarcity of tests of tunnel locomotives under operative conditions, tunnel construction being usually done under conditions and guarantees as to the time of delivery which permit no interruptions for the purposes of tests. During tests the locomotive was in front of the train when it moved tunnelwards, and behind when it moved out of the tunnel; in normal operation the opposite arrangement is of course used, since with a grade of 0.13 per cent and the heavy trains used, a break of a coupling would cause great danger unless the locomotive was always below grade from the train. To take care of that during the tests, there was always a second locomotive at some distance on the other side of the train. Both locomotives have been tested just as they were, without previous overhauling or even cleaning. Previous to the tests they were over a year in actual service on the construction. The air capacity of the tanks could be established only by calculation, and was found to be for the small locomotive 2250 l. (78.75 cu. ft.), and for the large locomotive 10200 l. (357 cu. ft.). The comparatively low temperature of preheating indicates that the smoke stack was chocked up, the temperatures obtained at the delivery tests having been considerably higher. The author states, however, that temperatures of 45 to 54 deg. cent. (113 to 129.2 deg. fahr.) in front of the low-pressure cylinder are about as high as one can go economically with this kind of locomotive where strong preheating permits the expansion of the air to be driven very high in the cylinder. The data of the tests are given in Tables 1 and 2.

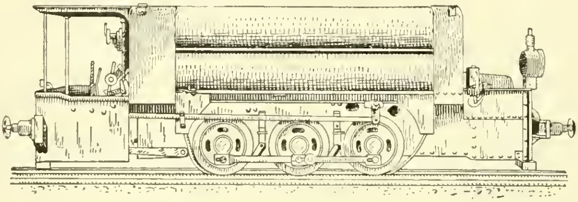

Fig. 1 Borsig Compressed Air Locomotive

See also Pumps and Fans.

TABLE 1 COMPRESSED AIR TUNNEL LOCOMOTIVES TEST

	European Units								
							Consumption of Air		
	Length of Run, m.	Gross Load, t.	Output, tkm.	Useful Load, t.	Tractive Effort Locomotive and Train, Kg.	Output I. H. P., Hr.	Total Cbm.	Per Tkm, Cbm.	Per H.p-Hr., Cbm.
Small Locomotive:									
Upgrade	1000	76.35	76.35	55.80	1627	6026	123.75	1.621	24.317
Downgrade	1000	76.35	76.35	55.80	60	0/222	4.50	0.059	24.324
	American Units								
	Miles	Tons Am.	Ton-Miles	Tons Am.	Lb.		Cu. Ft.	Per Ton-Mile, Cu. Ft.	Per H.p. Am.-Hr., Cu. Ft.
Upgrade	0.621	69.4	43.09	50.7	3579		4332	32	840
Downgrade	0.621	69.4	43.09	50.7	132		158	1.22	840
	European Units								
Large Locomotive:									
Upgrade	1870	183.20	324.58	138.2	3645	25245	459.00	1.34	22.611
Downgrade	1770	183.20	324.26	138.2	100	0.656	13.26	0.04	23.806
	American Units								
Upgrade	1.16	166.3	192.90	125.8	8019		16065	26.3	783
Downgrade	1.09	166.3	181.267	114.2	220		455	0.79	825

Cranes

New Crane Constructions for Special Purposes (*Neue Kranbauarten für Sonderzwecke*, C. Michenfelder. *Zeits. des Vereines deutscher Ingeniure*, vol. 56, no. 41, p. 1645, October 12, 1912. 5 pp., 15 figs. *d*). Description of some new types of cranes, mainly those for special purposes: thus there is a description of a *pickling* crane for lowering metal articles into a pickling bath and taking them out of it, where the difficulty lies in preventing the crane installation from being affected by the vapors of the pickling bath; it was found in this respect that with properly designed and enclosed motors, and sufficient ventilating and exhaust arrangement in the pickling room, there is little trouble due to the action of the gases. The article describes also some of the arrangements of the pickling room. The other kind of crane described in considerable detail is for ice-making plants.

TABLE 2 GENERAL DATA OF LOCOMOTIVES

	Small	Large
Number of cars	9	15
Kind of cars	box cars	15 tip wagons, 1 box car
Light weight	2.2 tons 4840 lb.	2.8 or 2.2 ton 6160 or 4840 lb.
Gross weight	8.4 tons 18480 lb.	11.6 or 8.4 ton 25520 or 18480
Duration of run, min	10.5	20.5
Length of run, m/yards	1000/1093	1870/2043
Speed m. per sec./ft. per sec	1.59/4.77	1.52/4.65
Initial pressure in the air tanks, atmospheres	84	68
Final pressure in the air tanks, atmospheres	29	23
Number of readings taken	10	19
Grand average pressure in the working flask, atmospheres	15	15.5
Temperature of the entering air at beginning of run:		
high-pressure cylinder, cent./fahr	....	80/176
low-pressure cylinder, cent./fahr	....	80/176
Temperature of entering air at end of run:		
high-pressure cylinder, cent./fahr	80/176	64/147.2
low-pressure cylinder, cent./fahr	45/113	58/136.4

The above are data for the run upgrade; the original article contains similar data for the downgrade run as well.

Internal Combustion Engines

Tests of an Internal Combustion Engine (*Versuche an einem Verbrennungsmotor*, Fritz L. Richter. *Dinglers polytechnisches Journal*, vol. 327, nos. 44 and 45, pp. 693 and 710, November 2 and 7, 1912. 7 pp., 18 figs. *ct*). Description of and data from *tests of an internal-combustion engine* made at the machine laboratory of the Royal Technical School at Chemnitz. The tests have shown that, when an *ordinary indicator* is used, the *friction losses* are so large as to make the data entirely unreliable; both during compression and expansion the pencil is behind the position where it ought to be, and the diagram is too large on both sides. There are also considerable difficulties in correctly determining the *temperatures*, especially that of the exhaust gases. The article contains many determinations of the tractive power of the engine, showing among other things how it and the efficiency of the engine are influenced by the cylinder lubrication.

ARIS CARBURETER (*Le carburateur Aris. La Pratique automobile*, vol. 8, no. 178, p. 3795, November 25, 1912. 2 pp., 5 figs. *d*). Description with several illustrations of the *Aris carbureter.* It has no float chamber. The fuel is admitted first to a horizontal passage provided with a needle valve, and then to a vertical passage at right angles to the first. This passage is also closed by a needle connected with a rotatable valve closing the passage from the air chamber of the carbureter to the cylinder in such a manner that it opens the passage to the fuel in proportion as the suction in the cylinder forces the valve up. The amount of fuel admitted may therefore be kept in constant ratio to that of air no matter what the speed of the motor may be, at least within certain limits, and the mixture remains practically always of the same richness.

NAPHTHALENE ENGINES (*Les moteurs à naphtaline*, L. Ventou-Duclaux. *La Technique moderne*, vol. 5, no. 9, p. 305, November 1, 1912. 2 pp., 2 figs. *d*).

UTILIZATION OF NAPHTHALENE AS A FUEL IN EXPLOSION MOTORS (*Utilization de la naphtaline comme combustible dans les moteurs à explosion. La Revue électrique*, vol. 18, no. 213, p. 376, November 8, 1912. 2 pp. *pt*). From a paper read on October 18, 1912, before the French Society of Civil Engineers by L. Ventou-Duclaux on the use of *naphthalene* in internal-combustion *engines* and the design of engines for this fuel. Naphthalene is one of the products of tar distillation separating in the region of 170 to 230 deg. cent. (338 to 446 deg. fahr.) although the usual boiling point is stated to be 217 deg. cent. (422.6 deg. fahr.). It is a solid having a melting point of 79 deg. cent. (174.2 deg. fahr.). To produce an explosive mixture in the cylinder of the engine, one must therefore not only liquefy it, but impart to it a fluidity comparable to that of other hydrocarbons. This is done either by utilizing the heat of cooling water, or by that of the exhaust gases; the piping carrying melted naphthalene to the carbureter being so arranged that its temperature should not go below 80 deg. cent. (176 deg. fahr.), in order to prevent possible crystallization of the naphthalene.

There are two methods of using naphthalene: dissolved in another hydrocarbon (benzole, gasolene, alcohol, etc.), or molten. On the first process is based the Rutgers carbureter, having an arrangement for producing the solution gradually, as it is wanted, so as not to cause any unnecessary deposits of naphthalene; so far, this process has not proved practical. The other process is represented by several designs of carbureters, some using the heat of the cooling water for melting the naphthalene (Deutz and the Schneider Company), while others (Chénier and Lion) use the heat of the exhaust gases. The latter two make the carbureter proper and the melting pot in one piece, and thus prevent the cooling of the molten mass in passing from the pot to the carbureter. In the Burlat carbureter the melting pot is separate from the carbureter proper, but the connecting pipe is surrounded by exhaust gases, so that the naphthalene reaches the carbureter at a comparatively high temperature. In the Bruneau carbureter both the melting pot and the carbureter proper are surrounded by the same jacket traversed by hot exhaust gases; the air for the explosive mixture is also preheated. In the Lion carbureter a sort of fractional distillation is used: naphthalene which does not have to be particularly pure in this case is first heated to the melting point in one reservoir, then passed on to a second reservoir where it is heated up to the boiling point, and admitted to the carbureter proper in the form of a gas; all impurities, such as tar, anthracen, tar oil, etc., having a higher range of distillation, simply remain in one of the reservoirs, and are cleaned away from time to time.

A 5-hr. test of an 8-h. p. engine, running at 595 r.p.m., showed a consumption of 0.342 kg. (0.75 lb.) per h.p.-hr., an interesting figure considering the low present price of naphthalene.

Besides its low price, the advantages of naphthalene are: safety of operation due to the fact that naphthalene is practically uninflammable and that should there appear a leak, some naphthalene would flow out, immediately solidify in the colder outside air, and stop all further leaks, thus preventing the danger so familiar to all users of gasolene; its chemical constituency is practically constant, thus considerably facilitating the engine design, and raising the average efficiency of its operation (it is a well-known fact that an engine designed for a certain kind of fuel and working with one which may have the same trade name, but different technical properties, may give quite unsatisfactory results). The disadvantage of the naphthalene motor lies in the complications at starting, but even this has little importance in the case of engines having a long average period of operation. The Schneider Company is proposing to use it for locomotive engines on the Transsiberian Railroad where steam locomotives have proved unsatisfactory owing to the large amount of mineral salts (up to 5 per cent) in the available feedwater.

MIXED EXPLOSION OR COMBUSTION AND COMPRESSED AIR ENGINES (*Moteurs mixtes à explosion ou à combustion et à air comprimé*, L. Letombe. *Mémoires de la Société des Ingénieurs Civils de France*, 7th ser., vol. 65, no. 359. 24 pp., 14 figs. *d*. Same article reprinted nearly in full in *La Revue électrique*, vol. 18, no. 214, p. 418, November 22, 1912). The title is somewhat misleading; what the author mainly discusses is the use of compressed air for self-starting. He describes his supplementary valve for the *self starter valve gear*, as well as an *air compressor* with an automatic arrangement for throwing it in and out of engagement.

UTILIZATION OF PEAT BOGS FOR THE PRODUCTION OF POWER AND ITS INFLUENCE ON THE DEVELOPMENT OF AGRICULTURE (*Die Ausnutzung der Torfmoore zur Krafterzeugung und ihr Einfluss auf die Kulturentwicklung*, C. Heinz. *Die Gasmotorentechnik*, vol. 12, no. 8, p. 121, November, 1912. 8 pp., 5 figs. *dg*). The article describes the Görlitz peat gas producer (cp. *The Journal*, July 1912, p. 1101) and special producer gas engine designed to use peat producer gas, as well as discusses the general problem of peat utilization in its relation to power production and agriculture. The author quotes the following data as to the cost of peat per ton in Germany (of 2200 lb.) in marks (1 mark = $0.238) : wages 0.26, power 0.24, drying 0.70, maintenance of plant 0.20, supervision 0.20, delivery cost 0.40, depreciation 0.50, total per ton of air dried peat: marks 2.50, and since 1 kg is required for the production of one effective horsepower-hour, the fuel cost of the latter is ¼ pf., or roughly 1/16 cent. Since, further, depreciation, interest, and other costs of a peat gas plant do not differ materially from those of other heat engine power plant costs, the peat gas power plant appears to be the cheapest in existence. Tests made by the Silesian Steam Engine Inspection Association show that as much power is derived from 1 kg peat in a peat gas producer engine as from 1 kg coal in a steam engine, while peat is available in many localities where coal is scarce and is much cheaper. The author also calls attention to the fact that the utilization of peat bogs for power production has the further advantage eventually of converting a useless, often harmful, bog into valuable agricultural land.

Motors at the Exhibition (*Les moteurs à l'Exposition*, P. James. *L'Aérophile*, vol. 20, no. 22, p. 512, November 15, 1912. 5 pp., 28 figs. *d*). Description of aeronautic engines at the Paris Salon of 1912. In the *Dhenain engine* (Fig. 2A) the valve gear is controlled by an eccentric in combination with a pinion of peculiar construction. By turning the eccentric this pinion is displaced, and so the admission, exhaust and direction of rotation of the engine may be regulated while the engine is running. The cranks are interchangeable, work all in the same plane, with the crankheads helicoidally arranged. The *Sira engine* (Fig. 2B) has eight cylinders arranged starwise, but neither cranks nor connecting rods. The piston gear is operated by two special cams, with a single rod. The *Esselbé engine* is original in design. The cylinders are replaced by a tore in which move diametrically opposite pistons A A', B B', each pair fixed on a plate CD. (Fig. 2C and D). These pistons open and close in a manner similar to that of shears. The space between the tore and the four pistons constitutes four chambers of which volumetric variations correspond to the four phases of a four-stroke cycle, the tore itself also rotating and thereby bringing the ports p and q of admission and exhaust to the places where they belong at the right times. To transform the reciprocating motion of the plates C and D into rotary, they are made solid with two pipes S and T concentrically around the axis of the engine and carrying at their other extremity two beams in articulated connection with the cranks E; these cranks actuate the central pinion of the tore. The article gives no data as to the efficiency of this engine. For the Esselbé engine Cp., also The Automobile, December 19, 1912, p. 1264.

A New Two-Stroke Cycle Engine (*Un nuovo motore a due tempi*, Marino Urbani. *L'Industria*, vol. 26, no. 44, p. 695, November 3, 1912. 1 p., 3 figs. *d*). Description of the *Urbani two-stroke cycle engine*. It consists essentially of the two cylinders 1 and 1′ (Fig. 3) joined in-U; one of them is provided with the exhaust port 2, the other with the openings for scavenging air 3 and gas 4. The air and gas pumps, which may also be independent of one another, are in the carters 5 and 5′. In the two cylinders move two pistons in full accord with each other having equal cranks making the same angles with the crankshaft. The action of the engine is simple. Suppose that the pistons are at the right-hand side dead points, and that to the right of them is a suitably compressed explosive mixture. When this is ignited an expansion follows, and the pistons move to the left. The exhaust ports 2 open first, and the pressure in the cylinder rapidly falls to about 0.3 to 0.4 kg/qcm (4.2 to 5.6 lb. per sq. in.) above atmospheric. At this point of the path of the piston the port 3 opens, admitting scavenging air previously compressed in 5′ to a pressure slightly above 0.3 to 0.4 kg/qcm (so as not to produce eddies in the cylinders). Still later, when the pressure in the cylinder has had time to fall below 0.3 to 0.4 kg/qcm, the gas comes through duct 7 and port 4 from pump 5 compressed to somewhat more than the pressure prevailing at that moment in the cylinder, so as to produce eddies and thus help the gas to make a thorough mixture with the scavenging air. On the back stroke of the piston, the ports close in the reverse order, first the gas, then the air, and finally the exhaust. The process is somewhat similar to that of the Oechelhäuser motor, but the engine may be made double acting, tandem, etc.

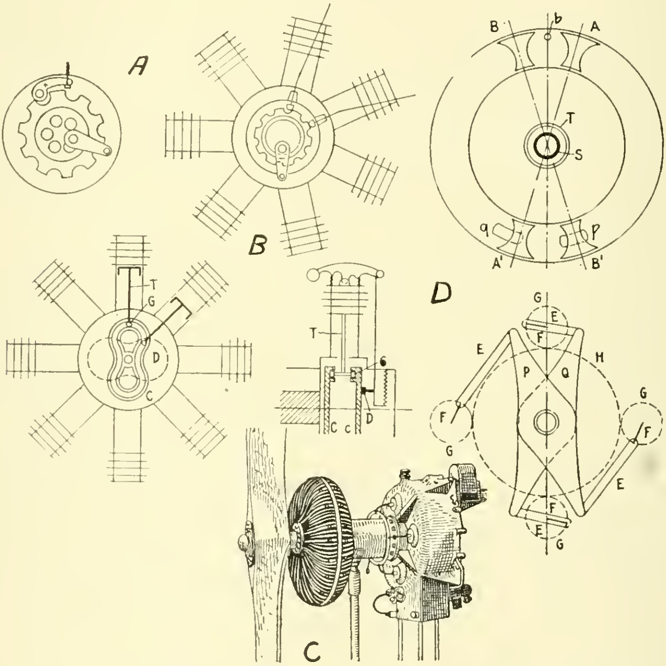

Fig. 2 *A* Dhénain Engine; *B* Siva Engine; *C* and *D* Esselbe Engine

The air regulator consists of a little piston 8 moving in the cylinder 9 having no head but provided in the middle with a circular passage 10 communicating with 5′. This little piston has an eccentric lagging 90 deg. with respect to the main crank. While the crank makes the angle 0 to 180 deg. corresponding to the period of intake of air, the piston oscillating between the positions *a* and *b*, lets open the annular passage 10 by which air penetrates to 5′. During the compression of the air, while the main crank passes through the angle 180 to 360 deg., the eccentric describes an angle 90 to 270 deg., and the little piston oscillates between *a* and *c* regulating the communication between 5′ and the atmosphere. This arrangement is interesting in that the opening and closing of the annular passage 10 occur always when the piston 8 is at its maximum velocity. A somewhat similar arrangement is provided with respect to gas.

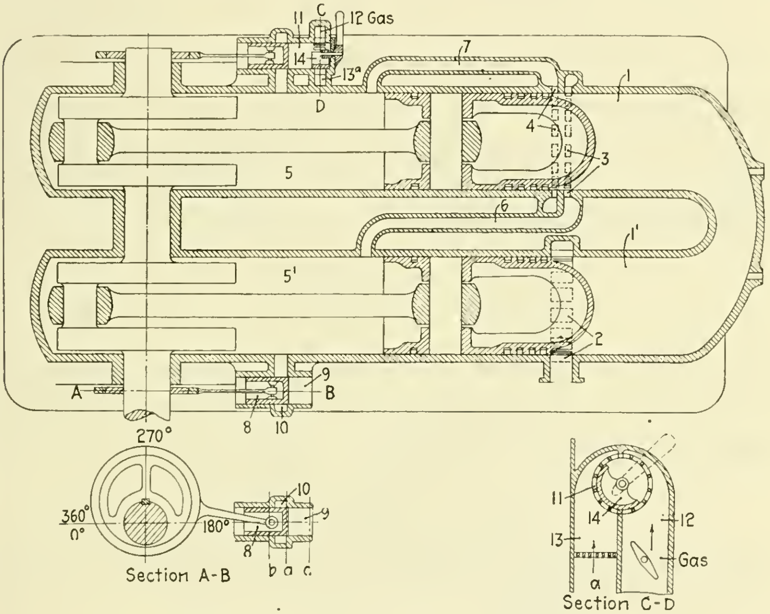

FIG. 3 URBANI TWO-STROKE CYCLE ENGINE

THE ERGON-KOSMOS PRODUCER GAS LOCOMOBILE AND ITS MANAGEMENT (*Die Ergon-Kosmos-Generatorgaslokomobile und deren Behandlung*, W. *Der praktische Maschinen-Konstrukteur*, vol. 45, no. 23, p. 392, November 7, 1912. 2 pp., 1 fig. *d*). Description of the Ergon-Kosmos locomobile, a stationary plant combining in one unit the gas producer, cleaner and locomobile.

Machine Shop

TESTING AND ESTIMATION OF MOLDING SAND (*Prüfung und Bewertung des Formsandes*, Carl Buderus. *Giesserei-Zeitung*, vol. 9, no. 20, p. 629, October 15, and p. 658, November 1, 1912. 6 pp., 1 fig. *pt*). After discussing the various stresses to which sand is subjected in the mold after the pouring of the metal, the author comes to the conclusion that its power of resisting them depends on what he terms its *plasticity*, and the whole problem of testing molding sand thus becomes one of finding a method for measuring plasticity.

If a sand cylinder of length of axis h and diameter D has the ability not to break when unsupported, and if $\frac{h}{D} = \frac{1}{4}$, then this may be taken as a unit of plasticity which increases with D and falls off with h. In testing plasticity, it is well to keep D constant, and to take h equal to $0.25D$; the plasticity is then determined from the pressure above atmospheric $\frac{pgr}{qcm}$ (p in grams per sq. cm) at which the sand column breaks, this being done in the following manner: if a sand cylinder of $h = 0.25D$ can maintain its shape unsupported at atmospheric pressure, but not at any above it, and if its plasticity be denoted by bi, its specific weight (in the column, i. e. compressed) by s, then

$$bi = 1 = bi_1 = \frac{r^2\pi hs}{\frac{r^2\pi h^2}{6}} = \frac{6s}{h}$$

since $\frac{r^2\,\pi\,h^2}{6}$ is the moment of resistance of the cylindrical column. If now a sand column has to support not only its own weight, but also an additional pressure $\frac{pgr}{qcm}$ its plasticity must be equal to

$$bi_2 = \frac{(r^2\pi\,.\,h's + r^2\pi p)}{r^2\pi\,.\,h'^2/6} = \frac{6\,(h's+p)}{h'^2}$$

which, to be expressed in the same units, must be divided by the value of bi_1, and this gives

$$bi_3 = \frac{6(h's+p)}{h'^2} : \frac{6s}{h} = \frac{(h's+p)h}{h'^2 s} = \frac{h^2 s+ph}{h^2 s} = 1 + \frac{p}{hs}$$

the last two values being for the case of $h' = h$. Since, however, the specific weights of various sands are very different from one another, either of the above expressions may give incorrect values. Thus, the plasticity of light sand, if expressed by one of the two latter equations would give too high values. The author recommends therefore the expression

$$bi = bi_2 = bi_1 \times bi_3$$

If this expression is used the hardness and toughness of the sand may be estimated from the power applied in stamping the sand, and its compression determined by separate experiments. The fire resistance of the sand, its permeability to gases, formation of the gases in the sand itself and its tendency to be fritted have also to be determined by separate experiments. In the second part of the article the author describes an apparatus for testing molding sand in which a layer of such sand, compressed to a certain amount may be subjected either to the action of gravity alone, or to an additional gas pressure as well. The apparatus appears to be simple in operation, cheap and easily handled.

A New Crucible Furnace (*Ein neuer Tiegelofen*, W. H. *Eisen-Zeitung*, vol. 33, no. 46, p. 809, November 16, 1912. 1 p., 1 fig. *d*). Description of a new crucible furnace invented by F. Lange in Memmingen, Germany. The furnace (Fig. 4) is contained in a sheet iron jacket protected by a fire-clay lining. This lining encloses a cylindrical chamber 11 containing a closely wound spiral pipe 12. In the center of the lined shaft is the cylindrical shaft for the reception of the crucible 9 and the coke charge 22 surrounding it. There are four small nozzles 6 opening in the direction of the crucible. Before passing out through stack 4, exhaust gases pass through the ducts 5 into the cylindrical chamber 11 where they preheat the pipes 12. From the top the crucible shaft is closed by the cover 3 rotatable about the hinge 19, the opening and closing of the shaft cover being further facilitated by the rope and counterweight arrangement, as

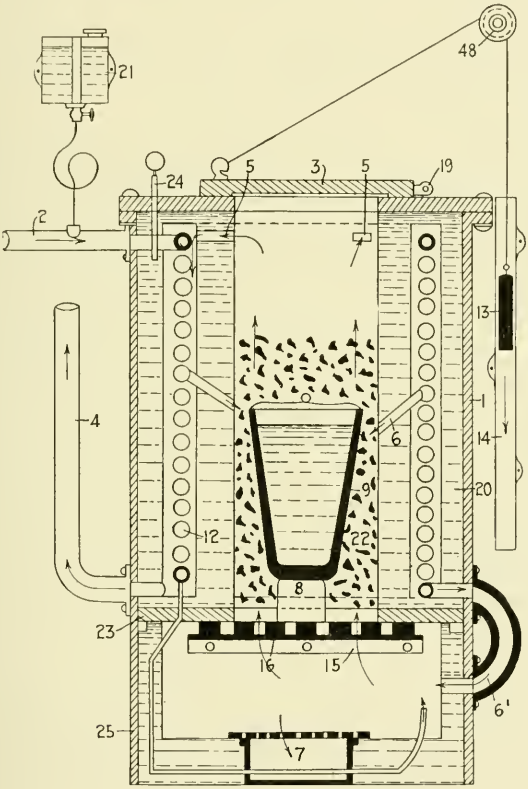

Fig. 4 Lange Crucible Furnace

shown at 13. The whole installation is placed on a bed plate 23 with a round hole in the middle for the admission of air to the crucible shaft; under the plate are located the grates 16 and the angle irons 15 supporting them. A small diameter pipe 25 goes from 12 through the water reservoir 7; the heat of this pipe brings the water up to the boiling point, and the steam, after having mixed with air saturated with kerosene vapors and coming from the pipe 6', passes into the crucible shaft and produces there an intense heat (the air becomes saturated with kerosene vapors while passing through the vessel 21). In spite of the intense heat produced, the consumption of coke is said to be small, while the life of the crucible which in this furnace does not come in contact with cold air at all, is materially longer than in other furnaces.

Annealing and Hardening by Gas (*Glühen und Härten mit Gas. Journal für Gasbeleuchtung*, vol. 55, no. 43, p. 1052, October 26, 1912. 2 pp., 4 figs. *ed*). Communication from the Stockholm municipal gas plant showing that gas is more economical and convenient than coal for such shop operations as annealing, hardening, tempering, etc. The tests were made in 1911 by engineer H. O. Ödlund at the works of the Separator Company, under regular shop conditions by men usually employed at the plant. Each test lasted a whole day, so as to keep the conditions as uniform as possible. The gas used was supplied by the municipal gas works, and had the lower heat value of 4700 WE (17800 b.t.u. per lb.), and a pressure of 40 mm (1.57 in.) water; for purposes of calculation the price of 11.2 Pf. per cbm ($0.77 per 1000 cu. ft.) has been accepted, this being the present actual rate there. The gas coke had a lower heating value of 7000 WE (27720 b.t.u. per lb.), and cost M 1.40 per 1 hl = 0.1 cbm = 3.5 cu. ft.). The coal was Silkworths blacksmith coal with lower heating value 7000 WE (27720 b.t.u. per lb.), and cost M 1.91 per hl.

Table 3 gives the comparative results with all three fuels. The article also contains descriptions of some of the furnaces used.

Mechanics

Reduction Gear for Coaxial Shafts (*Reduziergetrieb für gleichachsige Wellen*, R. Kommer. *Der Motorwagen*, vol. 15, no. 26, p. 618, September 20, 1912. 3 pp., 5 figs. *d*). The first part of this article has been abstracted in *The Journal*, November 1912, p. 1890. The second part containing a description of another type of the Kommer planetary gear, is here given as a reply to inquiries received. The gear shown in Fig. 5 consists essentially of the stationary external spurwheel a with which is in engagement an internal spurwheel b rotating about a crank pin or eccentric k placed centrically to the stationary spurwheel. The diameter of the wheel b exceeds that of the stationary wheel by twice the crank radius of the shaft k. With the inner spurwheel b is rigidly connected a second inner spurwheel c with which is in engagement the spurwheel d rigidly connected with the driven shaft. The spurwheel d is half as long as the crank radius of the shaft k. In the following description the radii of the wheels will be denoted by r, the numbers of teeth by z, with corresponding subscripts.

By analysing the mutual action of each pair of spurwheels, the author shows that in the action of the entire gear there correspond to the rotation of the crank k through an angle a: (a) a parallel sliding motion of the spur wheel c; (b) rotation of the toothed wheel d through the angle

$$\frac{a(z_b - z_a)}{z_b}$$

To the parallel sliding motion of the spurwheel c corresponds a rotation of the wheel d through an angle

$$\frac{a(z_d - z_c)}{z_d}$$

To the rotation of the wheel c corresponds a rotation of the wheel d through an angle

$$\frac{a(z_b - z_a)}{z'} \cdot \frac{z_c}{z_d}$$

TABLE 3 COST OF HARDENING WITH DIFFERENT FUELS

Article	Fuel	Actual Duration of Work per Piece, Sec.	Total Duration of Work per Piece, Sec.	Cost of Fuel per Piece, Pf.	Cost of Labor per Piece, Pf.[1]	Total Cost per Piece, Pf.
Mandrel	Gas	7.6	8.0	0.048	0.125	0.173
	Coke	13.7	16.3	0.098	0.254	0.352
	Coal	12.5	18.1	0.127	0.282	0.409
BearingPins	Gas	5.0	6.3	0.019	0.099	0.118
		8.1	9.6	0.054	0.149	0.203
		9.6	10.1	0.052	0.157	0.209
Screw-drivers	Gas	25.7	27.6	0.288	0.430	0.718
	Coke	40.6	50.7	0.363	0.787	1.119
	Coal	45.1	67.4	0.493	1.052	1.545

The heating of the furnace took practically no time with gas, and from 40 to 110 min. with coke and coal respectively.

[1] On the basis of Pf. 56.2, or $0.128 per hour.

To the rotation of the crank k through the angle a corresponds therefore a rotation of the spurwheel d through the angle

$$a\left[\left(\frac{z_d - z_c}{z_d}\right) + \left(\frac{z_b - z_a}{z_b}\right) \cdot \frac{z_c}{z_d}\right]$$

Example: let z_a be 80, $z_b = 100$, $z_c = 80$, and $z_a = 60$. Then

$$a\left[\frac{60-80}{60} + \left(\frac{100-80}{100}\right) \cdot \frac{80}{60}\right] = \left(-\frac{1}{3} + \frac{1}{5} \cdot \frac{4}{3}\right)a = -\frac{1}{15}a$$

Or the shaft rigidly connected with the wheel d moves with a speed equal to 1/15th that of the driving shaft in opposite direction.

If in the above formula the following values be substituted: $z_a = z_c = z_b - 4$, $z_d = z_b - 8$, then the transmission ratio would be as follows:

$$i = -\frac{16}{2z_b - 8z_b} \cdot a$$

which shows that with the same pitch of teeth in all spurwheels and the same differences of diameters, but various ratios of numbers of teeth, any desired ratio of transmission may be obtained. If the first pair of wheels is larger than the second, the transmitted motion is in a direction opposite to that of the driving shaft, and vice versa. The rotation of the wheel *d* rigidly connected with the driven shaft is due to the fact that the parallel sliding motion of the wheel *c* communicates to it a motion in a direction opposite to that of the driving shaft. These two opposite motions transmitted to the wheel *d* at the same time, produce a relative rotation of the wheel *d* in which only a part of the angular speed of the driving shaft is transmitted to that wheel, the magnitude of the angular speed transmitted being a function of the eccentricity and wheel ratio. The nearer the two opposite motions are to each other, the greater is the ratio of transmission of the gear, so that even a ratio 1 : ∞ may be obtained by making the two directions of motion equal to each other.

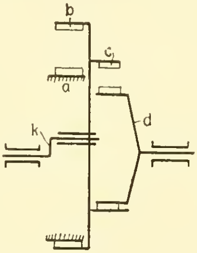

Fig. 5 Kommer Planetary Gear, Second Type

Screw Piles (*Pieux à vis et vis d'encrage, Nouvelles annales de la construction*, 6th ser., vol. 9, p. 164, November 1912, 1 p., 19 figs. *d*). Description and drawings of various types of screw piles, as well as a short bibliography of same.

Contribution to the Theoretic Study of Flexure (*Contribution à l'étude théorique de la flexion*, P. Keelhof. *Annales de l'Association des ingénieurs sortis des écoles spéciales de Gand*, ser. 5, vol. 5, no. 3, p. 274, 1912. 14 pp. *mt*). A mathematical investigation consisting in an application of the equation of Maurice Lévy to a determination of the cases where the usual formula of flexure gives correct results as far as stresses are concerned, whether shearing, or with respect to the moment of flexure; a short discussion is appended on elastic deformations.

The Law of Viscosity of Fluids (*Das Gesetz der Viskosität der Flüssigkeiten*, A. Batschinski. *Physikalische Zeits.*, vol. 13, no 24, p. 1157, December 1, 1912. ½ p., 1 fig. *et*). Advance notice of an article to be published. The author claims to have established that *the viscosity of a fluid is a function of its specific volume.* Attention is called to this notice because, as has been shown by Ubbelohde (*The Journal*, August 1912, p. 1247), " viscosity is the only factor affecting the coefficient of friction," and all oils having the same viscosity have the same coefficient of friction in a bearing. It is often easier, however, to determine the specific volume of an oil than its viscosity, and the former may thus be used for the estimation of lubricating qualities of liquids.

Selection of Power (*Die Wahl einer Betriebskraft*, F. Barth. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, nos. 41 and 42, October 12 and 19, 1912, 15 pp., 1 fig. *es*). The author does not attempt to establish any universal rules for the selection of power, but shows that for large power units, say over 6000 h.p. the steam turbine has to be used, while in other cases choice lies between a heat engine and an electric motor. Utilization of heat of exhaust gases in the case of internal-combustion engines is of advantage in the case of large gas engines in such as large steel works and mines, but one must not forget that when the engines work only intermittently, the supply of heat will also be intermittent. As the load factor of the plant and local fuel price decrease, the cheapest engine becomes the most economical, which means for large outputs at least, the steam engine. With a high load factor and high price of fuel the Diesel engine is to be preferred, but for power reserves and low load factor plants they are of advantage only in cases where particular stress is laid on the facility of, and speed in starting. Whether a suction gas plant is advisable in any particular case, is mainly a matter of the price of fuel: it is, when there is available fuel at a low price per heat unit, while in large plants the preliminary gasification of the fuel is of advantage in that it permits of the recovery of such valuable by-products as nitrogen and tar. The author shows that the introduction of the naphthalene, Diesel and suction gas engines, and steam superheat in steam engine plants have deprived the central station of a large amount of its previous importance, since the isolated plant is now about as economical in its operation as the large central plant, particularly since it does not have to meet the expense of laying the cable net. The author goes so far as to state that the central plant can compete in the cost of producing power with the Diesel engine only where it has a steady market for its waste heat.

The article contains a large amount of interesting statistical material.

Pumps and Fans

Calculation of Centrifugal Pumps (*Berekening van de centrifugaal-pomp*, P. F. A. von Wolzogen Kühr. *De Ingenieur*, vol. 27, no. 45, p. 897, November 9, 1912. 5½ pp., 6 figs. *tA*). An attempt to give an exact and practical theory of centrifugal fans without using Euler's fundamental formulae. Fig. 6 is a cross-section, normal to the axis of a fan. The polar equations of motion are:

$$dm\,(r''-r\theta'^2)=-dp.\,sb \qquad [1]$$

$$\frac{dm}{r}\,\frac{d(r^2\theta)}{dt}=dT \qquad [2]$$

where $w_n=r\theta$ is the absolute tangential velocity, and $w_r=r''$ absolute radial velocity. From the equation of continuity it follows that $sb.w_r=$ constant of $rb.w_r=$ constant, since s (length of the element) is proportional to r. Equation [2] can also be written as

$$rdT = \frac{dm}{dt} d\ (w_n r) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3]$$

and since $rdT = dM$, a moment, and $\frac{dm}{dt}$ is the mass flowing per second, which in the stationary state is constant and equal to M_{sec} [3] may be written as

$$dM = M_{sec}.d(w_n r) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3a]$$

which, on being integrated, gives

$$M = M_{sec.}\ [(w_n r)_2 - (w_n r)_1] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [4]$$

From equation [1] the author derives

$$w_r dw_r - \frac{w_n^2}{r} dr + \frac{g}{\gamma} dp = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [5]$$

which permits of the calculation of the increase in pressure when w_n is known as a function of r. The tangential component w_n consists of ωr where ω is the angular velocity of the axis, and of relative velocity $r \chi$, the origin of this velocity component in the tangential direction being the deflection of its blade curvature from the radial direction, so that

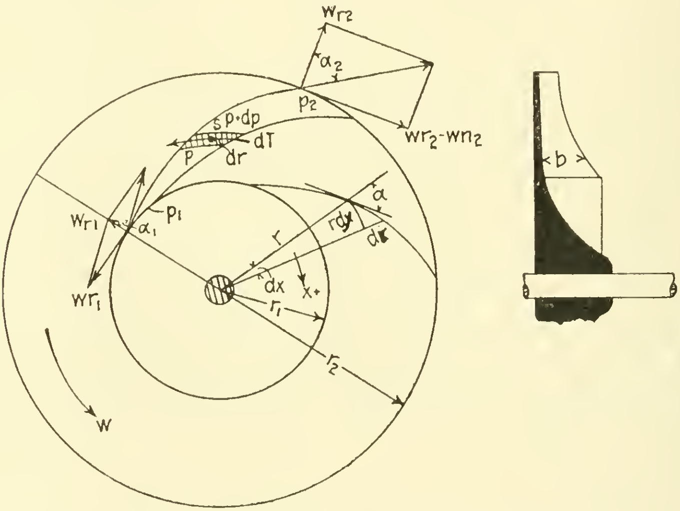

Fig. 6 Fan Wheel, Section of Blade and Stress Diagram

$$w_n = (\omega + \chi') \quad \text{or} \quad w_n = (\omega - \chi') \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

the latter for the case when χ is in the direction of rotation opposite to that of ω.

Further

$$r\frac{d\chi}{dt} = r\frac{d\chi}{dr}\cdot\frac{dr}{dt} = \omega r - w_n \quad \text{and} \quad r\frac{d\chi}{dr} = \frac{\omega r - w_n}{w_r} \ldots\ldots\ldots\ldots [8]$$

But $r\frac{d\chi}{dr} = tg\ \alpha$, and therefore

$$tg\ a = \frac{\omega r - w_n}{w_r} \qquad [8a]$$

And since w_n at entrance and exit are fixed, the following two equations hold:

$$tg\ a_1 = \frac{\omega r_1}{w_{r1}} \qquad [8b]$$

and

$$tg\ a_2 = \frac{\omega r_2 - w_{n2}}{w_{r2}} \qquad [8c]$$

The second of these equations may also be written in the form

$$tg\ a_2 = \frac{(\omega r_2)^2 - \omega (w_n r)_2}{\omega r_2\ w_{r2}} = \frac{u_2^2 - C}{u_2\ w_{r2}} \qquad [8d]$$

If H. Lorenz's value for the wheel constant $C = \frac{1}{\eta}\left(gh + \frac{c^2}{2} \right)$ be accepted; u_2 is here the peripheral speed of the fan.

The radii of curvature of the blades may be taken with reference to the angles φ_1, and φ_2, in which case w_n becomes known as a function of r, and vice versa.

From [8c] it follows that when r_2 is small and w_{n2} large, then a_2 must be negative (leading blade): in the opposite case a_2 is positive (lagging blade). To be able to realize any desired angle, the simplest way is to select for the blade curvature an arc of a circle. It is further unnecessary to determine w_n as a function of r in order to determine the increase in pressure; the author indicates another method, but develops it only partly.

The author investigates further the various forms of fan blades, gives a graphical method for the construction of their radius of curvatures, as well as a discussion of the processes of flow of the fluid in the fan.

Steam Engineering

NEW BOILER CONSTRUCTION FOR STEAM TURBINE PLANTS WITH SPECIAL REGARD TO WATER TUBE BOILERS. (*Neuere Dampfkessel Konstruktionen für Dampfturbinenkraftwerke unter besonderer Berücksichtigung der Steilrohrkessel*, Fr. Münzinger. *Zeits. für das gesamte Turbinenwesen* vol. 9, no. 31, p. 488, November 10, 1912. (Continuation of a series of articles). Description and drawings of the Borsig high capacity boiler and of the Glogner boiler. Although with a considerable expenditure of time and labor the headers of two-header tubulous boilers may be made so as to give entire satisfaction, it is a matter requiring care, and one that cannot be handled by the methods of mass production. Babcock & Wilcox have introduced the sectional construction which permits of rapidly making up a boiler of any height, but even this method is expensive on account of numerous tube joints. To avoid this, Engineer Glogner of Charlottenburg, Germany, uses instead of numerous tubes of small diameter a few tubes of comparatively large diameter carrying inside tubes of smaller diameter and having their ends beaded in horizontal sectional headers (Fig. 7A);

the front ends of the inner tubes are provided with reducing sleeves which are beaded in the front headers while the rear ends are held tight by nickel steel nuts (in the first Glogner boilers these nuts were protected by cast-iron caps, but experience has shown that such protection is superfluous). To clean the boiler, the nuts are loosened, and the inner tubes removed by a blow of a wooden mallet; in putting the boiler together again it is sufficient to have the inner tube loosely beaded in: the path of the gases is so arranged that the temperature of the external wider tube is higher than that of the inner tubes, and the former in expanding makes a tight joint. Fig. 7B is a section through the boiler; the return path of water is through tubes beaded in the upper part of the boiler, and therefore heated but little. It is claimed that the Glogner boiler is of greater simplicity than the usual watertube boiler: where the latter with a heating surface of 250 qm (say 2500 sq. ft.) has to have 150 tubes with 300 joints, a Glogner boiler of equal capacity has only 48 tubes with 48 nuts. In testing a Glogner boiler in 1910, when this type was still to some extent in the experimental stage, Professor Josse found a boiler efficiency of 75 per cent, temperature of feedwater 50 deg. cent. (122 deg. fahr.), that of superheated steam 283 deg. cent. (541.4 deg. fahr.), and of flue gases 296 deg. cent. (564.8 deg. fahr.), the absolute steam pressure being 12.3 atmospheres.

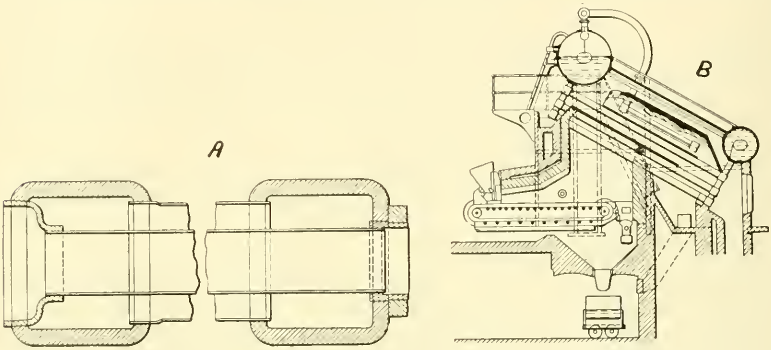

Fig. 7 Glogner Water Tube Boiler and Boiler Tube

High Capacity Water Tube Boiler Plant of the Municipal Central Station in Brandenburg a.H. (*Hochleistungs-Wasserrohrkessel-Anlage im Elektrizitätswerke der Stadt Brandenburg a.H.*, Mahr. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 42, p. 1708, October 19, 1912. 3 pp., 6 figs. *de*). Data from tests of 2 high capacity marine type boilers installed at the municipal plant of the city of Brandenburg, Germany. The construction of the boilers permitted the maximum production of 480 kg. steam per qm (9.9 lb. per sq. ft.) of ground area, while 1 sq. ft. of boiler heating surface required only 0.0725 sq. ft. of ground area. This shows the advantages of this type of boilers for use in places where the ground value forms a particularly important item in the cost of the station. The efficiency of the boiler plant is given as 79.0 per cent without feed heater, and 83.3 per cent with feed heater.

Corrosions in Steam Boilers (*Des corrosions dans les chaudieres a vapeur*, La Maestra. *La Technique moderne*, vol. 5, no. 10, p. 357, November 15, 1912, 6 pp. *ptA*). The author begins with the well-known fact that steam boilers are most affected by corrosion at the transverse riveting seams and at the curvature of the stamped parts; it is also very usual, particularly in the case of locomotive boilers, to find strongly corroded places on the inside of the boiler opposite its intermediate supports. Forney stated that when steel and iron are subject to corrosion and in parts submitted to powerful tensions at the same time, the corrosion will be stronger at the places of greater tension. From a study of a number of locomotives the author found that when the supports adhere closely when cold, and consequently produce a strong tension when the locomotive is hot, there are clearly pronounced corrosions along the supports, from 4 sometimes to as much as 7 mm (0.157 to 0.229 in.) deep, but when there was a play of about 1.50 mm (say 0.06 in.) between the boiler and its support when cold, no such corrosion was observed. The same explanation is given for corrosion affecting the stamped end-sheets of boilers. Stamping is at best a delicate operation, and the end sheets are subject to great tensions, so that if the work is not done well, or the material is somewhat defective, corrosion is likely to start.

On the same basis of corrosion being a function of the stress in the respective boiler sheet, the author proceeds to establish a formula for the speed of corrosion and time which it takes for corrosion to penetrate to a certain depth, e.g. that at which it becomes dangerous for the boiler. He derives the following two formulae:

$$V = P\frac{C}{s-y} \quad \text{and} \quad x = \frac{y}{2PC}\,(2s-y)$$

where V is the speed of corrosion, P pressure per unit, C constant $= \frac{PD}{2}$, s thickness of sheet, y depth of corrosion. It is worth noticing that the second equation, the law of the progress of corrosion, is that of a parabola.

To find how long it will take for corrosion to reach a certain depth, the author assumes that if in time t_1 a corrosion of depth h_1 is produced, to produce a corrosion of depth h_n, it will require some time $t_n = Kt_1$, where K is a certain coefficient to be determined. He further shows that K is the ratio of proportionality.

$$\frac{x_{h_n}}{x_{h_1}} = \frac{x'_{h_n}}{x'_{h_1}} = K$$

K has been determined experimentally for various values of the depth of corrosion h and thickness of plate s, and brought together in Table 4. The following example is quoted to show how this table and method are to be used. A locomotive boiler has cylindrical sheets 15 mm (0.59 in.) thick, with a diameter of 1315 mm (51.5 in.), rated at 10 kg (142 lb. per sq. in.); the boiler is subjected to a stress of 4.38 kg (62.2 lb. per sq. in.), while the maximum stress is 7 kg (99.4 lb. per sq. in.). The sheets may therefore be used until they have attained the minimum thickness of 9.39 mm.

but to simplify the calculation the depth of permissible maximum corrosion is found to have corroded to a depth of 3 mm (0.118 in.). By substituting is assumed here to be 6 mm (0.236 in.). After 4 years of work, the boiler values from Table 4 for K and the above equation for x, the following are found:

$$t_4 = \frac{104}{81} 0.48 = 61 \text{ (5 years and 1 month)}$$

$$t_5 = \frac{125}{81} 0.48 = 74 \text{ (6 years and 2 months)}$$

$$t_6 = \frac{144}{81} 0.48 = 85 \text{ (7 years and 1 month)}$$

Or after three years and one month more the corrosion in the boiler will pass the safe limit. In a supplementary discussion the author attempts to trace the spread of corrosion rifts to original deficiencies in the plate due to irregularities in casting.

TABLE 4 TIME COEFFICIENTS FOR CORROSION IN BOILERS

Depth of Corrosion	Time Coefficient for Thickness of Plate s in Mm.					
	14	15	16	17	18	19
1	27	29	31	33	35	37
2	52	56	60	64	68	72
3	75	81	87	93	99	105
4	96	104	112	120	128	136
5	115	125	135	145	155	165
6	132	144	156	168	180	192
7	147	161	175	189	203	217
8	...	176	192	208	224	240
9	...	...	...	225	243	261
10	...	...	...	...	...	280

The author shows how to apply these equations to the determination of the most economic thickness of plates for a given pressure, or pressure for a given thickness of plates. A boiler has to be made to work with a pressure p, to be of diameter D, R being the coefficient of resistance of the plates, and the thickness has to be selected between s and s_1, the latter being larger; let t be the time required for corrosion to the depth h to be produced, and t_1 the time for corrosion to the depth h_1 such that $s - h = s_1 - h_1$; then, as the author shows,

$$\frac{t_1}{t} - 1 = \frac{(s_1 - s + h)\ (s_1 + s - h)}{h(2s - h)} - 1$$

by which the advantage of a thicker or thinner plate may be determined. Sometimes it may be of advantage to adopt the thicker plate only for the two lower half rings of the cylindrical part of the boiler instead of copper rings which are used for protecting that part of the boiler from too rapid corrosion.

The above applies in the first place to locomotive boilers.

Thermodynamics

A Technical Process for the Determination of Heat Conduction in Plate-Shaped Bodies (*Ein technisches Verfahren zur Ermittlung der Warmeleitfahigkeit plattenförmiger Stoffe*, R. Poensgen. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 41, p. 1653, October 12, 1912, 5 pp., 10 figs. e4). The Nusselt process for the determination of the coefficient of heat conductivity (the heating element is placed in the center of a ball which is filled with the material under test; the coefficient of heat conductivities is determined from the amount of heat produced at the heating element which is in turn determined from the strength of the heating current and electrical pressure, and from the amount of heat transmitted to the surface of the ball) can be used only for materials plastic enough to fill a ball, and having equal coefficients of heat transmission in all directions. For materials which have to be tested for heat transmission in the shape of plates Gröber used an arrangement in which two layers of the material under test enclosed a plate-shaped heating element; the disadvantage of this arrangement lay in the escape of heat sidewise along the edges of the heating element not covered by the plates of material under test. To avoid this the author encloses the main heating element into an auxiliary one having the same temperature as the first and arranged to prevent the sidewise escape of heat without materially affecting the amount transmitted through the plates of the material tested. In Fig. 8 H_p is a square heating element lying between two plates P_1 and P_2 of material under test, of equal thicknesses and of the same area as the heating element. Around the last and at a distance of 2.5 to 4 cm (0.97 to 1.57 in.) is placed a ring-shaped heating element H_r, 11 cm (4.3 in.) broad, covered on both sides by plates R_1 and R_2 of some heat insulating material of the same thickness as the plates under test. The other sides of the plates P and the rings R are covered by water cooled jackets K_1 and K_2. Care should be taken that the temperature of H_p should be equal to that of H_r, as well as that the temperatures of K_1 and K_2 be equal to one another. Under these

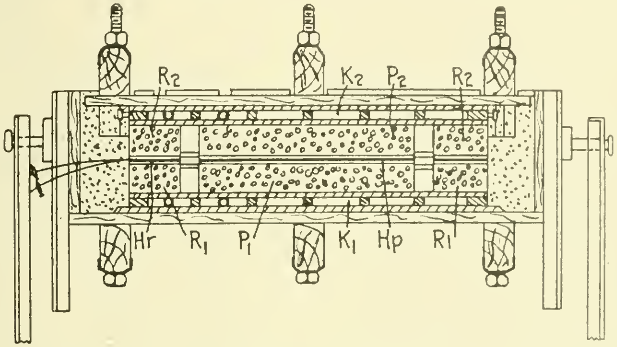

Fig. 8 Poensgen Arrangement for Determining the Coefficient of Heat Transmission of Plate Shaped Bodies

conditions the isotherms ought to lie in the planes parallel to the surface of the plate, and the coefficient of heat conductivity may be determined from the formula:

$$\lambda = \frac{Q \cdot \delta}{2F(t_1 - t_2)}$$

where Q is the amount of heat supplied to the heating element in calories, t_1 and t_2 are the temperatures of the warmer and colder surfaces of the plates under test in deg. cent., δ their thickness in m, and F their area in qm.

For heating elements the author used fabrics woven of constantan wire and asbestos fiber. The article contains data from tests made by the author at the laboratory of the Technical High School in Munich, of which the most important are reproduced in Table 5 (cp. a similar table from the tests of Biquart, *The Journal*, December 1912, p. 2105).

TABLE 5 COEFFICIENTS OF HEAT TRANSMISSION

Material	Specific Weight		Coefficient of Heat Transmission at 20 Deg. Cent.
	Kg/Cbm	Lb. per Cu. Ft.	
Linoleum	1183	74	0.16
Wood normal to the fiber	546	34.2	0.13
Wood parallel to the fiber	551	34.6	0.30
Teak wood normal to fiber	642	40.5	0.15
Teak wood parallel to fiber	604	37.8	0.32
Oak normal to fiber	825	52	0.18
Oak parallel to fiber	819	51.2	0.31
Asbestos slate	1783	112	0.19
Gypsum plates with enclosed pieces of cork	685	43	0.25
Building gypsum	1250	78.5	0.37
Wood and brick building wall	...	...	0.28
Machine made brick	1672	106	0.45
Brick wall	1850	116.2	0.35
Concrete (1:4, dry)	2180	136.5	0.65
Concrete (1:12, fresh)	2050	128	0.70

Among other things established by the author was a confirmation of the fact found by Nusselt, viz. that the coefficient of heat transmission increases as the temperature rises.

Miscellanea

Progress in Refuse Destructor Furnace Engineering (*Fortschritte auf dem Gebiet der Müllverbrennung*, H. Schaefer. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 35, no. 48, p. 505, November 29, 1912. 3 pp., 10 figs. *d*). The great difficulty in refuse destructor furnace work was the *method of handling ashes*, a problem all the more difficult owing to the fact that the ashes and dust formed from 6 to 10 per cent of the weight of the refuse burned. Handling by manual labor proved to be both an expensive and an unhygienic proceeding. A suction fan placed between the ashpit and exit was experimented with, but the hot ash and dust handled was destructive to the fan blades. An attempt to meet the difficulty by placing the fan behind the exit proved to be equally unsuccessful owing to the trouble experienced in keeping the installation in working order. Hartmann & Co., of Offenbach a.M., Germany, have devised an improved system described in the present article, the main feature of which consists in producing the suction by a specially constructed pump (no details as to its construction are given), and in moving the dust and ashes through closed pipes exclusively. The article describes in some detail the piping system in the Hartmann installation in the municipal refuse destructor plant in Frankfort, where it was found to give entire satisfaction.

MECHANICAL TILLING AT THE BOURGES EXHIBITION (*Le labourage mécanique a l'Exposition de Bourges*, H. Pillaud, *La Technique moderne*, vol. 5, no. 9, p. 310, November 1, 1912. 6 pp., 5 figs. *adA*.). A very interesting account of the competitive tests of *farm tractors* at the Bourges Exhibition (France, October 1912), together with a description of the best types of French tractors. The tests were made under various conditions, closely approaching those of actual work (e.g. in muddy and rocky ground) and were on the whole very satisfactory. Both internal-combustion engined and steam tractors were represented.

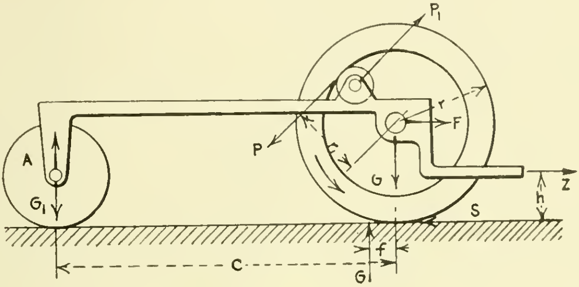

FIG. 9 DIAGRAM OF STRESSES IN A MOTOR PLOW

THE MOTOR PLOW FROM THE POINT OF VIEW OF THE AUTOMOBILE ENGINEER (*Der Motorpflug vom Standpunkt des Automobiltechnikers*, K. S. *Auto-Technik*, vol. 1, no. 19, p. 35, October 11, 1912, appended to *Allgemeine Automobil-Technik*, vol. 4, no. 41 *dt*). Examination of the principles of design of motor plows, mainly with respect to their difference from that of motor cars, with discussion of the construction of the motor, cooling, transmission gear, etc. Of interest is the discussion of the difference in the action of the flywheel in the two cases, as illustrated by the following numerical example. Let an automobile weigh 1000 kg (2200 lb.), and move at 70 km (43.5 miles) per hour. Let the motor make 1800 r.p.m., the weight of the flywheel be 25 kg (55 lb.), and its diameter through the center of gravity 400 mm (15.7 in.). The kinetic energy of the whole car is then:

$$\frac{mv^2}{2}=\frac{1000}{2\times 9.81}\cdot\left(\frac{70}{3.6}\right)^2=19200 \text{ mkg.}$$

That of the flywheel:

$$\frac{m_1v_1^2}{2}=\frac{25}{2\times 9.81}\cdot\left(\frac{3.14\times 0.4\times 1800}{60}\right)^2=1810 \text{ mkg.}$$

The tractor weighs 10000 kg (22000 lb.), and has a speed of 1 m (3.28 ft.) per sec. Its motor makes 350 r.p.m., while the weight of the motor is 900 kg (1984 lb.), and its radius 1 m (3.28 ft.). The kinetic energy of the tractor is then:

$$\frac{mv^2}{2}=\frac{10000}{2\times 9.81}\cdot 1=510 \text{ mkg.}$$

while that of the flywheel is:

$$\frac{m_1v_1^2}{2}=\frac{900}{2\times 9.81}\cdot\left(\frac{3.14\times 1\times 350}{60}\right)=15400 \text{ mkg.}$$

This comparison shows that while in the case of the automobile the resistances are supposed to be taken care of by the kinetic energy of the whole car, and the kinetic energy of the flywheel supplies only about one-tenth of it, the kinetic energy of the flywheel in the tractor is about thirty times that of the tractor itself. That indicates also the kind of motor best adapted for tractor work; if the total energy of the above flywheel were given up in one second, that would be equivalent to an output of about 200 h.p., or nearly four times the regular motor output: this shows the advantage of using multicylinder motors which can be equipped with lighter flywheels, and still produce a uniform turning moment.

The author also calls attention to the necessity of carefully considering in the case of a motor plow the variations of the vertical axial pressure due to the driving and external forces. When the motion is uniform, in addition to the axial load G (Fig. 9) there are acting the crown pressure P and the tractive effort Z on the rear wheel. The rolling resistance of the front wheels produces the force F acting backwards, the moment of the resistance at road surface of the rear wheels being equal to $G.f$. On the wheel circumference is acting the adhesion force S. The horizontal force acting on the axis is therefore $F+Z=S$, and the driving moment is:

$$P \,.\, r_1 = G \,.\, f + S \,.\, r$$

The pressure on the teeth P of the small driving toothed wheel produces an equal but oppositely directed reaction P_1 on the bearing.

The tractive effort Z, when applied as is usually done, above the point of support of the carriage, produces a decrease of load on the front axle, by producing a moment $Z.h$ tending to lift the front part of the tractor off the ground.

The following numerical example may show with forces of what magnitude one has to deal in the case of tractors. A tractor of 9000 kg (say 20000 lb.) exerts, when at rest, a pressure on the road surface in front equal to 3000 kg (say 6600 lb.) and behind 6000 (say 13400 lb.). The axle base is 4 m (13.1 ft.), the diameter of the driving wheels 2 m (6.56 ft.). The motor capacity is 50 h.p., the efficiency of the plant down to the driving wheels is 0.8, so that 40 h.p. are transmitted to the rear axle. The speed is 1 m (3.28 ft.) per sec. Of the motor output 50 per cent are consumed by the resistances of the tractor itself, 50 per cent are used to drive the plow.

SCHIESS AUTOMATIC FIRE ALARM AND EXTINGUISHER (*Extincteur-avertisseur automatique d'incendie, systéme Schiess. Le Génie Civil*, vol. 61, no. 23, p. 467. October 5, 1912. ½ p., 1 fig. *d*). The apparatus is shown in Fig. 10. When the temperature rises beyond a certain point, the thermometer *T* closes the current, and makes the electric bell *S* ring, and the electromagnet *E* energized. The electromagnet attracts the soft iron piece *F* which releases the catch hook *C*, and this lets the reservoir *R* tilt down about the axis *X*. During this tilting of *R* the percussor *P* breaks the glass tube *A* filled with hydrochloric acid which flows into the reservoir *R* filled with carbonate of soda, and produces an energetic evolution of carbon dioxide. This gas driven by the pressure inside the cylinder flows

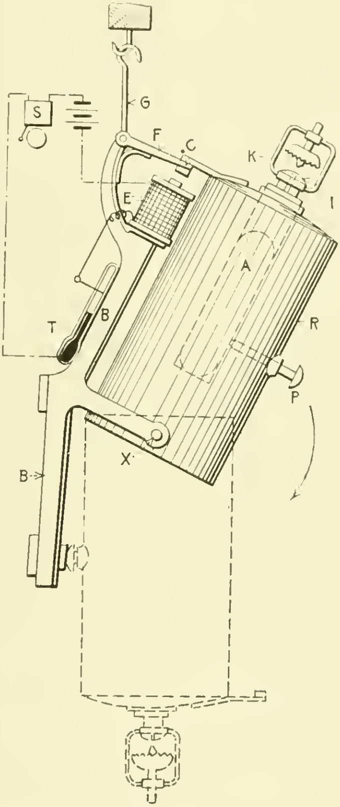

FIG. 10 SCHIESS AUTOMATIC FIRE ALARM AND EXTINGUISHER

with considerable violence through the opening *I*, and striking the shield *K*, spreads brushwise to all sides. It would appear, however, that some of the mixture of the acid and carbonate of soda would be carried away by the gas and thrown to all sides, which might be undesirable under certain conditions.

On the Installation and Operation of Wood-Drying Plants (*Uber die Einrichtung und den Betrieb von Holztrocknungsanlagen*, Max Dribbusch. *Werkstattstechnik*, vol. 6, no. 19, p. 497. October 1, 1912. 5 pp., 14 figs. *p*). A discussion of the principles of installation and operation of wood-drying plants written in a thoroughly practical manner; particular requirements for the more important kinds of wood are indicated, and the advantages and disadvantages of various systems of compressed air application discussed.

Safety Appliances for Use with Tanks for the Storage of Explosive Liquids: Automatic Extinguishing Devices, Dr. Flach's System, patented in Germany (*Sicherheitsmassnahmen bei Tanks für Lagerung feuergefährlicher Flüssigkeiten durch selbsttätig wirkende Löschvorrichtungen System Dr. Flachs D.R.P.*, E. Schultze. *Allgemeine österreichische Chemiker- u. Techniker-Zeitung*, vol. 30, no. 20, p. 153. October 15, 1912. 2½ pp., 1 fig. *d*). Description of a new system of *fireproof tanks* for the storage of dangerous liquids like benzine or gasolene, based on a combination of the principle of the Davy safety lamp with that of producing low temperatures by expanding compressed non-oxidizing protective gases. The surface of the liquid is protected by one or more fine wire screens which take care of temperature variations, prevent the explosions of the liquid, and act as cooling surfaces. In addition, the pressure produced by the small explosions under the wire screen (just as in a Davy lamp) automatically sets the tank in connection with steel flasks filled with non-oxidizing gases (carbon dioxide, nitrogen); these gases expand on reaching the wire net, and thereby produce a powerful cooling which prevents the spread of fire, and cools off the wire net itself. This system has been approved by the Berlin factory inspectors.

Submarine Sled for Dräger Divers (*Unterseeschlitten für Dräger-Taucher. Periodische Mitteilungen aus dem Draegerwerk Lübeck*, no. 4, October 1912. *d*). The construction of diving apparatus without air pipes, such as the apparatus of the Drägerwerk Lubeck (The Journal, October 1912, p. 1584) and Westfalia (The Journal, November 1912, p. 1900) made the diver to a considerable extent independent of the boat acting as his base of operation, and this made it desirable to devise some means for making his locomotion more rapid than walking along the bottom, which would give him more time under water for placing torpedoes, inspecting the location of submarine obstructions to navigation, searching for wrecks, etc. The Drägerwerk Lubeck designed for this purpose what they call a *submarine sled*, or a boat provided with air tanks and vertical rudder, both arranged in such a way that by suitably operating them the boat may be either kept at the surface, or lowered to the bottom. Cp. *Scientific American*, December 21, 1912, p. 534.

The Education of Molders and Founders at the Royal Trade School

FOR THE METAL INDUSTRY AT ISERLOHN (*Die Ausbildung der Former und Metalgiesser an der Königl. Fachschule für Metalindustrie zu Iserlohn*, H. Krause. *Giesserei-Zeitung*, vol. 9 no. 20, p. 623. October 15, 1912. 6 pp., 5 figs. *d*). Description of the course for molders and founders at the Iserlohn Trade School. The course in the school is equivalent to a period of apprenticeship, and therefore the program includes a large amount of practical work, and avoids all theory that is not of recognized value to the practical foundryman. The program of the school is quoted in detail.

DURALUMIN (*Duralumin*, L. M. Cohn. *Elektrotechnik und Maschinenbau*, vol. 30, nos. 39 and 40, pp. 809 and 829, September 29 and October 6, 1912. 10 pp., 11 figs. *ep*). Data from an investigation of the properties of *duralumin* previously published by the same author in *Zeits. des Vereines zur Beförderung des Gewerbefleisses*, 1911, no. 1. The first part of the article (in no. 39) contains among other things information as to substances attacking duralumin; the second part (in no. 40) is devoted to its use in electric conductors.

Supplementary References

EXPERIMENTS OF THE FIRM A. BORSIG IN TEGEL NEAR BERLIN WITH DUPLEX-SPRING VALVES IN HIGH-SPEED WATER PUMPS (*The Journal*, October 1912, p. 1577). A long explanation why some pumps with both valves positively loaded do start, and why they did not in the tests made by the author: *Die Förderteehnik*, vol. 5, no. 11, p. 262, November 1912.

NEW EXPERIMENTS ON THE COMBUSTION OF NITROGEN IN EXPLODING GAS MIXTURES (*The Journal*, October 1912, p. 1564). Description of the application of this process to the production of nitric acid from atmospheric nitrogen, and apparatus used, in *Industria*, vol. 26, no. 46, p. 739, November 17, 1912.

VALVELESS PUMP "BAVARIA" (*The Journal*, August 1912, p. 1253). Detailed description and drawings in *Pompe sans soupape, Portefeuille economique des machines*, 5th ser., vol. 10, November 1912, p. 170.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(XXIII)

ARTICLES IN PERIODICALS[1]

Gasoline Car-Ferry for an Electric Railway. *Engineering News*, November 21, 1912. 3 pp., 7 figs.

Car-ferry and transfer boat used on the Ohio River between Evansville, Ind. and Henderson, Ky.

Gas Pressure Regulations of the Public Service Commission for Companies in Borough Manhattan, New York City. *Engineering News*, October 31, 1912. 2½ pp.

Liquid Fuels; Their Production Peculiarities and Investigation, L. Schmitz. *Zeitschrift des Vereines deutscher Ingenieure*, October 26, 1912. ⅙ p.

A review of a book of the above title.

Motor Ship Eaveston, The Single Screw. *The Engineer* (London), October 25, 1912. 5 pp., 9 figs., 1 curve. *dpA*.

This ship is 275 ft. 9 in. long, 40 ft. 6 in. beam, 4310 tons displacement, fitted with an 800 h.p. Diesel engine 90 r.p.m. at 9 knots.

Motor Ship Rolandseck. *The Engineer* (London), November 22, 1912. 2½ pp., 6 figs. *dpA*.

Note and description of the Carels-Tecklenborg Diesel engines while on trial trip.

Oil as Fuel, The Use of, A. O. Krieger. *Engineering News*, November 21, 1912. 1 p.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

REPORTS OF MEETINGS

BOSTON MEETING, DECEMBER 20

A meeting of the Society was held at Boston, Mass., on December 20. when Prof. H. W. Hayward of Massachusetts Institute of Technology presented a paper on The Testing Laboratory and the Constructing Engineer. He described the equipment and functions of the different types of testing laboratories (works, government, technical schools, etc.), and brought out various misconceptions prevailing even among intelligent engineers as to what can and cannot be done in the laboratory, and as to what constitutes a reasonable specification for any particular class of material or structure. The value of the laboratory in determining compliance with specifications, also the value of laboratory tests in furnishing practical standards for incorporation in specifications, were indicated at some length, and a list of problems was given which had actually been put up to laboratories to solve. Examples were given of the amusing and absurd requirements which occasionally creep into well regulated specifications, and a number of slides were shown illustrating various points covered by the address. In closing the author appealed for a closer coöperation between the manufacturers and contractors and the laboratory to the end that more tests be made of full size specimens and of structures under conditions of actual use.

The paper was discussed at length by Prof. I. N. Hollis, Mem.Am.Soc. M.E., Prof. Geo. F. Swain, Mem.Am.Soc.M.E., and Mr. Woods.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

On December 4 the Armour Institute of Technology Student Branch held its third regular meeting. The speaker of the evening was Mr. S. Rosenzweig of the Erie City Iron Works, who presented an illustrated lecture on Poppet Valve Engines and Superheated Steam. Since the use of superheated steam is not general in this country the paper was of great interest to all and was discussed by Professors G. F. Gebhardt, Mem.Am.Soc.M.E., and H. L. Nachman, and A. W. Semerak.

COLUMBIA UNIVERSITY

The student branch at Columbia University held a meeting December 6, and Mr. Place of Warren and Whetmore, architects for the New York Central Railroad, gave a talk on the Mechanical Features of the New Grand Central Terminal.

CORNELL UNIVERSITY

Sibley College Student Branch held a meeting December 11 at which Prof. R. C. Carpenter, Mem.Am.Soc.M.E., spoke on The Practical Problems of Smoke and Dust Prevention.

LEHIGH UNIVERSITY

A meeting of the Lehigh University Student Branch was held November 19 when Professor Schweinitz was elected honorary chairman. The Electric Lighting of Steam Trains was presented by Mr. Johnson; Some Efficiency Secrets by Mr. Brooke; and Mr. Butterfield spoke briefly of the cleaning of blast furnace gas for use in engines; dry, wet and mechanical scrubbers were also discussed.

On December 10 Mr. Janeway presented a paper on An Economical Method for Producing Sound Steel, and Lieut. W. D. Greetham, government inspector for the navy at the Bethlehem Steel Works, spoke on Naval Ordinance and Gunnery.

POLYTECHNIC INSTITUTE OF BROOKLYN

At a meeting of the Polytechnic Institute Student Branch on December 7, Geo. A. Orrok, Mem.Am.Soc.M.E., lectured on Hydro-Electric Development with particular reference to the water power plant being built near Chattanooga on the Tennessee River. Discussion was offered by Professor Ennis, Mem.Am.Soc.M.E., Messrs. Adler, Heustis and other student members.

PURDUE UNIVERSITY

An unusual interest is being taken in the Purdue University Student Branch this year. Regular meetings are held every two weeks and are well attended. The meeting on December 3 was addressed by Mr. Shaw, western sales manager of the Westinghouse Company, who gave the history of turbine development, discussed features of the construction of the most modern turbines and condensors, and gave a clear idea as to the field of the turbine as a prime mover.

STEVENS INSTITUTE OF TECHNOLOGY

Stevens Institute of Technology Student Branch held a meeting November 26 at which Prof. F. R. Hutton, Honorary Secretary of the Society, read a paper on The Testing of the Automobile Motor. Secretary Calvin W. Rice told of the progress of the work of the student branches and Past-President Alex. C. Humphreys closed the meeting with a few appropriate remarks.

On December 6 a paper by Carl F. Dietz, Mem.Am.Soc.M.E., on the Manufacture of Abrasive Materials was presented. Messrs. Kinsey, Vander Veer, Smith, Aronson and Kepke entered into the discussion.

George R. Henderson, Mem.Am.Soc.M.E., read his paper on The Development of the Locomotive at the December 10 meeting. Messrs. Vander Veer and Henry took part in the discussion.

SYRACUSE UNIVERSITY

A student branch was established at Syracuse University December 3, 1912, and the following officers have been elected: Honorary Chairman, Prof. W. E. Ninde; Chairman, O. W. Sanderson; Corresponding Secretary, R. A. Sherwood.

UNIVERSITY OF ARKANSAS

At the December 2d meeting of the University of Arkansas Student Branch, Prof. B. C. Carnahan read a paper on Gas Producers, and Producer Gas Analysis, which was followed by a second by John Danner on The Setting of Steam Engines.

UNIVERSITY OF CINCINNATI

On December 3 Mr. Rosenzweig of the Erie City Iron Works read his paper on Superheated Steam and Poppet Valve Engines before the University of Cincinnati Student Branch. He showed the economy of superheated steam and the adaptability of the poppet valve to its use. His sixty lantern slides showed the detailed construction of engine and valve gear in particular. Messrs. A. K. DeLeeuw, J. B. Stanwood, B. S. Hughes, R. S. Brown and Prof. J. F. Faig, all members of the Society, were present and took part in the discussion.

UNIVERSITY OF KANSAS

The University of Kansas Student Branch held a meeting December 5 and several members of the senior class gave reports of the annual inspection trip to Keokuk, Iowa, where they visited the Mississippi River Power Company's hydro-electric plant. Mr. Knerr read a paper on The Economics of the Mississippi River Power Project at Keokuk, Iowa; Mr. Plank reported on the stream flow of the Mississippi River at this point, and Mr. Tangeman gave an account of the electrical installation and power distribution of the plant.

UNIVERSITY OF ILLINOIS

On December 6 the University of Illinois Student Branch held its regular bi-monthly meeting. Mr. S. Rosenzweig of the Erie City Iron Works read his paper on Poppet Valve Engines and Superheated Steam, following which there was an interesting and general discussion.

The members of The American Society of Mechanical Engineers at the University of Illinois, with the heads of the several engineering departments, gave a dinner to Dean W. F. M. Goss of the College of Engineering on December 13 at the University Club in Urbana, as an expression of their appreciation of the honor paid him by his election to the presidency of the Society. Among the guests present were the members of the Council of Administration of the University of Illinois and Dean Charles H. Benjamin of Purdue University. Prof. Ira O. Baker acted as toastmaster and the following toasts were given: The National Engineering Societies, Professor Arthur N. Talbot; Congratulations from the University, Dean Eugene Davenport of the College of Agriculture; Greetings from Purdue University, Dean Charles H. Benjamin; Response, Dean W. F. M. Goss.

On December 18, a special engineering convocation was held to permit the general faculty and the students in the College of Engineering to express their appreciation of the honor paid Dean Goss. Brief addresses were made by President Edmund J. James and Prof. A. N. Talbot, after which Prof. Ira O. Baker presented to Dean Goss a beautifully engrossed testimonial signed by representatives of the faculty and the various engineering organizations at the University of Illinois.

UNIVERSITY OF MISSOURI

The University of Missouri Student Branch held a meeting November 18 at which Messrs. Heileman and Klein read a paper on The Diesel Engine. On December 2 Messrs. Pierce and James presented a paper on The Present Day Aspect of Industrial Management. Short talks on the subject by Prof. Hibbard and Messrs. Wesson and Fessenden followed.

UNIVERSITY OF NEBRASKA

A meeting of the Student Branch of the University of Nebraska was held December 10 at which Messrs. Toney and Goddard presented The Purchase of Coal by Specification for discussion. The subject was treated under the following heads: origin of the purchase of coal by specification; disadvantages; advantages; methods of buying with data. Professor Baker criticised the paper.

UNIVERSITY OF WISCONSIN

Before a meeting of the University of Wisconsin Student Branch on December 12, Prof. C. C. Thomas gave an account of the New York meeting of the Society held November 12, when E. B. Passano's paper on Measuring Efficiency in Manufacturing was read.

WASHINGTON UNIVERSITY

A joint session of the Washington University student branches of the American Institute of Eelectrical Engineers and of the Society was held on December 11. Fred. H. Kohlmeyer of the mechanical engineering department read a paper on Scientific Shop Management, and C. E. Wright of the electrical engineering department gave a talk on the Transmission and Distribution System of the Illinois Traction System. A general discussion followed.

YALE UNIVERSITY

At a meeting of the Yale Mechanical Engineers Club held December 10, William Kent, Mem.Am.Soc.M.E., spoke on Engineering Opportunities.

NECROLOGY

RALPH P. BADEAU

Ralph P. Badeau was born in Brooklyn, N. Y., October 26, 1886, and received his early education at Rutgers College Preparatory School of New Brunswick, N. J., and at the Battin High School of Elizabeth. He was graduated from Stevens Institute of Technology in the class of 1909, and immediately afterward entered the employment of Purdy and Henderson, structural engineers of New York. While with them he had charge of the design of the McNeill Building, Chicago, Ill., and of the crane runway for Inland Steel Company. In November 1910 he became assistant superintendent of the A. & F. Brown Company of Elizabeth, N. J. where he was employed until his death, July 20, 1912.

GEORGE H. SCHULTE

George H. Schulte was born in Cincinnati, Ohio, April 16, 1848, and at the age of sixteen went to Little Rock, Ark., where he was employed in the Fones Brothers' hardware store. He became its manager in 1870. Twelve years later he went to Milwaukee, Wis. where for the next twenty years he was superintendent of the Milwaukee Harvester Company, having full charge of the mechanical part of the works. Under his management the harvester was brought to so high a degree of perfection that it found a world-wide market. The company was purchased by the International Harvester Company of America in 1904, and Mr. Schulte remained as vice-president and general manager for one year, when he was compelled to retire on account of ill health. From 1906 to 1908 he was director and general manager of the J. I. Case Threshing Machine Company of Racine, Wis. The last three years of his life were spent in retirement and traveling. He died July 29, 1912.

FREDERICK H. CRABTREE

Frederick H. Crabtree was born at Ebbw Vale, England, October 5, 1863, and died in Anaconda, Montana, August 3, 1912. His early education was obtained in the Cardiff High School, and in 1876 he entered as an apprentice the Blaina Iron Works of Blaina, England, where he remained until 1881. Subsequently he was employed by the Thames Iron & Shipbuilding Company, London; Crossley's Woolen Factory, Halifax; Blaina Blast Furnace Works; Ebbw Vale Steel Works; and as chief engineer in charge of the Pyle Works coal washing and coking plant, Blaina.

Mr. Crabtree came to America in 1888 and accepted a position as master mechanic with the Rock Springs Coal Company of the Union Pacific Railroad. In 1890 he moved to Anaconda, Mont., where he held a number of responsible positions, among which was the supervision of the installation of the machinery in a 50-ton gold mill for the Republic Reduction Company, Republic, Wash. The last position he filled was as assistant superintendent of power plants of the Washoe Smelter Company, from which he resigned three years ago.

Mr. Crabtree is the patentee of a number of devices. In 1887 he was granted an English patent on improvements on a rotary steam engine; in 1904 on a pneumatic massage apparatus; in 1905 on an automatic cut-off steam valve; in 1910 on a paper fastener and on an auxiliary rim and tire protector.

ARTHUR C. SCOTT

Arthur C. Scott was born January 27, 1870 at Northbridge, Mass. He moved to Worcester when eleven years old and obtained his education in the public high school there and the Worcester Polytechnic Institute. His first employment was in the freight office of the New York, Providence & Boston Railroad and two years later he went to work for the Draper Machine Tool Company of Worcester where he remained for seven years. In 1903 Mr. Scott entered the employ of the Norton Company as traveling salesman, and in 1909 was sent to Great Britain to sell grinding wheels and to investigate conditions abroad. He died November 22, 1912.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The list of "men available" is made up from members of the Society and good men not members. Information will be sent upon application.

POSITIONS AVAILABLE

01 Engineer with practical experience to supervise the running and construction of a large plant, as assistant to chief engineer and to represent him during his absence; must be able to take charge of drawing-room and design of buildings and machinery. Knowledge of manufacturing sugar preferred. State previous experience, age and salary desired. Apply through the Society.

02 First class steam engineer for a large steel plant in Pittsburgh district. Give experience in detail, education, age and salary wanted.

03 Young mechanical engineer of ability and experienced in the efficiency methods of shop practice and setting of rates, having a suitable personality for prosecuting this work, to act as assistant to superintendent in charge of work. Salary $100 to $150. Position one of promise.

04 Young man on time-study work for New Jersey concern; must be practical mechanic technically inclined, preferably one with experience in armature and coil winding and general electrical work.

05 Man for production department, experience in technical lines, preferably in electrical work. Salary $100 upward. Location, New Jersey.

06 Works manager, trained manufacturing executive, experienced in problems of management of men, efficiency and factory accounting, with college preparation in chemistry, and with experience in the management of chemical, electro-chemical or metallurgical industries.

07 Expert cost-reduction man, thoroughly experienced in modern shop practice, to devote entire time to development and application of cost reduction methods in Canadian plant, manufacturing air compressors, rock drills, hammer drills and minor allied lines. Apply through the Society.

08 Young engineer to handle technical work in the drawing-room and testing plant of Ohio concern; to be in charge of experimental work with opportunity to branch into the commercial side.

09 Mechanical engineer, technical graduate for perfection of invention

for railroad use. Experience in automatic signal devices preferred. Location, New York. Apply through the Society.

010 Technical man to handle the engineering positions, correspondence and office routine for New York concern engaged in employment work.

011 Draftsman specializing in photographic machinery and apparatus. New York concern.

012 Salesman for New York concern manufacturing instruments for indicating, recording and controlling temperature and pressure.

13 Southern university desires instructor in mechanical engineering to take position at once. Desires graduate of high-grade engineering college, who can teach machine design, mechanical laboratory, engines and boilers. To the right man assurance of steady advancement in salary and rank. Salary to start $1000.

014 Water meter expert and designer. Location New York. Apply through the Society.

015 Air compressor expert and designer. Location New York. Apply through the Society.

016 Efficiency engineer with full knowledge of machines, machine tools and the various and proper rates of cutting the different metals usually encountered in machine shop practice; his duties will be to deal entirely with the machine shop end of the plant. Apply through the Society.

017 Draftsman, accurate, rapid; must have experience on steel stamping, drawing and forming tools, other experience valuable. State experience, references, and salary desired.

MEN AVAILABLE

1 Graduate. mechanical engineer, ten years' experience in design, testing and operation of mechanical and electrical plant equipment, especially qualified to handle men, desires connection with manufacturing or power production company preferably in New York. At present employed in responsible executive position.

2 Technical graduate, age 37, practical mechanic with ten years' experience in executive capacity, mill engineering, power generation and transmission, etc. Desires position with large progressive concern in New England as factory engineer or works manager.

3 Position as manager or superintendent by Member. Thoroughly posted on modern factory methods and can show results in cost reduction; good executive. Prefers location north of Ohio River. At present employed.

4 Production manager familiar with machine tools, engines, automobiles, valves and fittings. Qualified to construct and apply special tools and machinery to assist in production. Knowledge of labor-saving management including time studies, planning, routing, shop costs and premium systems.

5 Graduate, mechanical engineer, fifteen years' experience, desires position as works manager or superintendent. Familiar with modern methods

of handling men and machines to produce profitable results. At present employed, but desires a position with greater opportunities. Can furnish good references.

6 Junior, age 30, technical graduate, with experience in design, construction, operation and maintenance of power plants and sub-stations, testing electrical and other machinery, desires responsible position with large manufacturing plant or contractors on power or hydroelectric plant work. Salary $175 to $200 per month.

7 Sales manager, desires to connect with concern where opportunity will be given to produce maximum results. Broad gage man with initiative and exceptional ability acquired by wide experience in mechanical and electrical manufacturing, having worked from drafting-room to superintendent in bronze, iron and steel foundry, and machine shop.

8 Sales engineer, with office and shop experience in designing, wishes to change. Experienced in plant lay-out and equipment in detail; graduate Munich Polytechnic. Will consider salary and commission basis. Desires New York location.

9 Position desired as works manager, preferably with new company; long experience as factory man and engineer; now head of engineering department of large company.

10 Position desired as mechanical and electrical superintendent to take charge of entire power department of manufacturing concern. Thoroughly understands practical, economic and reliable operation; ten years' experience.

11 Technical graduate, twenty-five years' experience in invention and design of power machinery especially gas and steam, desires position.

12 Mechanical engineer, technical graduate, five years' experience in works engineering, gas engines and pumps, desires position as assistant to executive or manager.

13 Technical graduate eighteen years' experience in shop, drafting-room and executive positions, desires position as chief engineer, resourceful in designing and working out new ideas. Salary $2500.

14 Junior, age 27, technical graduate, six years' experience erecting, operating, and testing large gas engines, and various types of producers; gas engine and producer design in connection with trouble and experimental work, desires position where such experience will be of value. Location immaterial.

15 Technical graduate, thirty years' experience in designing, building and managing mills for cotton, cotton oil and by-products. Competent in development of new schemes connected with the cotton industry from the plantation to the most remote by-product.

16 Junior member, age 29, married, five years' experience in machine shop and general manufacturing, three years' as works engineer, desires position as assistant superintendent or with firm doing power plant or hydroelectric work.

17 Engineer, age 39, technical education, executive ability, experienced in designing, erecting and operating large gas and oil engines and producers, also manufacturing steam engines and turbines; electrical experience.

18 Member, technical graduate, desires position as sales engineer, experienced as skilled mechanic, chief draftsman and superintendent of construction of power plant equipment.

19 Mechanical engineer or chief draftsman with executive ability. Thorough experience in steam power plant design, heating and ventilating, mechanical equipment of round-houses, etc. Technical graduate.

20 Mechanical engineer, Stevens Institute graduate. Experience in plant superintendence and construction, power house engineering, boiler design, manufacturing and sales. Acquainted with territory in vicinity of New York City.

21 Mechanical engineer, Cornell graduate, experience in construction and superintendence of manufacturing mills; familiar with construction and operation of plants for manufacture of explosives, also manufacture of nitric and sulphuric acids and nitrate of ammonia. Desires position in operating or engineering end of this line of work.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

Account of the History and Present State of Galvanism, John Bostock. *London, 1818.* Gift of L. B. Lent.

American Machinist Grinding Book, F. H. Colvin and F. A. Stanley. *New York, McGraw-Hill Book Co., 1912.*

The American Society of Mechanical Engineers. Trans. 1880, vol. 1; 1881, vol. 2; 1882, vol. 3. *New York, 1892.*

Amerikanische Hüttenwerke, Peter Eyermann. (Sonderabdruck aus der "Zeit. des Oesterr. Ingenieur-und Architekten Vereines" 1912, Nr. 33.) *Wien, 1912.* Gift of author.

Artistic Bridge Design, H. G. Tyrrell. *Chicago, 1912.*

Atlantic Deeper Waterways Association. Resolutions adopted by and address on The New Jersey Link, F. W. Donnelly. *New London, Conn., 1912.* Gift of New Jersey Ship Canal Commission.

Bau und Betrieb von Prall-Luftschiffen, Richard Basenach. *Frankfurt a. M., 1912.*

Baylor University. Annual Report of the President and Trustees, October 1912. *Waco, 1912.* Gift of university.

Beitrag zur Berechnung der Luftschrauben, Claude Dornier. *Berlin, 1912.*

Belgium. Ministere de L'Industrie et du Travail. Statistique des Industries Extractives et Metallurgiques et des Appareils à vapeur en Belgique 1911. *Bruxelles, 1912.* Gift of Ministere de l'Industrie et du Travail.

Billings, Charles E. (newspaper clipping). Gift of Billings & Spencer Co.

Complete Treatise on Electricity, in theory and practice with original experiments, T. Cavallo. ed. 4, vol. 1. *London, 1795.* Gift of L. B. Lent.

Congreso Cientifico (1° Pan Americano). Ciencias Naturales, Antropologicas y Etnologicas. vol. 3, pt. 17. *Santiago de Chile, 1912.* Gift of congress.

Connecticut State Board of Education. Announcement of the State Trade School of Bridgeport 1912-1913. *Bridgeport, 1912.* Gift of board.

Connecticut Trade Education Shop, 1912-1913. *New Britain, 1912.* Gift of state board Bridgeport, Conn.

Design of Simple Roof-Trusses in Wood and Steel, M. A. Howe. ed. 3. *New York, J. Wiley & Sons, 1912.*

A text-book embodying lectures to mechanical engineering students of Rose Polytechnic Institute, in which the author is professor; of especial interest from the fact that it treats of wood trusses, on which subject very little is published.

Electrical and Mechanical Equipment of the New Passenger Terminal of the Chicago and North Western Railway, Samuel G. Neiler. Reprint from Journal of Western Society of Engineers, vol. 16, December 1911.

FIRE TESTS WITH GLASS. British Fire Prevention Committee, No. 172. *London, 1912.*

FOWLER'S MECHANICAL ENGINEER'S POCKET BOOK 1913, edited by William H. Fowler. *Manchester, England, Scientific Publishing Co.*

A new edition of a very useful tool. If it is better than the previous editions, it is a very good book indeed.

DIE GRUNDLAGEN DER DEUTSCHEN MATERIAL UND BAUVORSCHRIFTEN FÜR DAMPFKESSEL, R. Baumann and C. V. Bach. *Berlin, 1912.*

DIE HYDRAULISCHEN SCHMIEDE-PRESSEN, Franz Jos. Hofmann. *Berlin, 1912.*

LUFTSCHRAUBEN. LEITFADEN FÜR DEN BAU UND DIE BEHANDLUNG VON PROPELLERN, Paul Béjeuhr. *Frankfurt a. M., 1912.*

MODERN ORGANIZATION. AN EXPOSITION OF THE UNIT SYSTEM, C. DeLano Hine. *New York, Engineering Magazine Co., 1912.*

NATIONAL ELECTRIC LIGHT ASSOCIATION. Michigan Section First Convention, 1912. *Detroit, 1912.* Gift of association.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS. Proc. 41st annual meeting. *Boston, 1912.* Gift of association.

NEW ORLEANS SEWERAGE AND WATER BOARD. 25th Semi-Annual Report, 1912. *New Orleans, 1912.* Gift of board.

NEW YORK CITY BOARD OF WATER SUPPLY. Contract 79, 94, 109. *New York, 1912.* Gift of board.

NEW YORK ELECTRICAL SOCIETY. no. 15. *New York, 1912.* Gift of society.

NEW YORK STATE EDUCATION DEPARTMENT. ORGANIZATION AND INSTITUTIONS October 1911. Gift of education department.

LES NOUVELLES RECHERCHES EXPERIMENTALES SUR LA RESISTANCE DE L'AIR ET L'AVIATION FAITES AUX LABORATOIRES DU CHAMP DE MARS ET D'AUTEUIL, M. G. Eiffel. *Paris, 1912.* Gift of author.

OHIO ENGINEERING SOCIETY. Report of 33d Annual Meeting, 1912. *Cleveland, 1912.* Gift of society.

ORGAN FÜR DIE FORTSCHRITTE DES EISENBAHNWESENS. Vierzehnter Ergänzungsband. Fortschritte der Technik des deutschen Eisenbahnwesens in den letzen Jahren. pt. 8. *Wiesbaden, 1912.*

AN OUTLINE OF THE METALLURGY OF IRON AND STEEL, A. H. Sexton and J. S. G. Primrose. ed. 2. *Manchester, Scientific Publishing Co., 1912.*

The authors are members of the faculty of the Glasgow Technical College, and this book is prepared primarily for use as a textbook. The authors point out that "no textbook can be more than a guide to reading," and ample reference is made in the footnotes to the original sources of information. This valuable feature is almost unique. The book has a more complete index than is usually found in English books. The treatment of alloy steels, electric furnaces, and heat treatment, although necessarily brief, is representative of the most modern practice.

PRATIQUE DES TURBINES MARINES, L. Jauch et A. Masméjean. *Toulon-Paris, 1912.*

RAILWAY LIBRARY, 1911, Slason Thompson. *Chicago, 1912.* Gift of author.

REPORT ON LEGAL AND FRANCHISE MATTERS CHARTER AMENDMENTS TO THE BOARD OF SUPERVISORS CITY OF SAN FRANCISCO, B. J. Arnold. Preliminary Report No. 13, Part 1, submitted November 5, 1912. Gift of author.

REPORT ON RELIEF OF TRAFFIC CONGESTION ON LOWER MARKET STREET, B. J. Arnold. Preliminary Report No. 6, submitted October 30, 1912. Gift of author.

SELECT BIBLIOGRAPHY OF RECENT PUBLICATIONS ON THE HELPFUL RELATIONS OF EMPLOYERS AND EMPLOYED, compiled by Winthrop Talbot. *Cleveland, 1912.*

STEAM POWER PLANT ENGINEERING, G. F. Gebhardt. ed. 3. *New York, 1912.*

THE STERLING DESTRUCTOR. *New York.* Gift of Griscom-Russell Co.

STRUCTURAL DETAILS OF HIP AND VALLEY RAFTERS, C. T. Bishop. *New York, J. Wiley & Sons, 1912.*

The book is written for the use of structural draftsmen. The author is a member of the faculty of Sheffield Scientific School.

STUDY OF THE COLLECTION AND DISPOSAL OF THE SEWAGE OF THE RICHMOND DIVISION. Preliminary reports on the disposal of New York's sewage, September 1912. *New York, 1912.* Gift of Metropolitan Sewerage Commission of New York.

STUDY OF TROLLEY LIGHT FREIGHT SERVICE AND PHILADELPHIA MARKETS IN THEIR BEARING ON THE COST OF FARM PRODUCE, C. L. King. *Philadelphia, 1912.* Gift of Philadelphia Department of Public Works.

TABLE OF ANGLES OBTAINABLE ON THE DIVIDING HEAD, C. W. Ripsch and P. W. Hirsch. *1912.* Gift of C. W. Ripsch.

TEMPERATURMESSMETHODEN, Bruno Thieme. *Berlin, 1912.*

THEORY OF ENGINEERING DRAWING, Alphonse A. Adler, Mem.Am.Soc.M.E. *New York, D. Van Nostrand Co., 1912.*

The author is a member of the faculty of the Brooklyn Polytechnic Institute, and the work is designed for use as a textbook. It aims to give a more complete presentation of the theory at the basis of descriptive geometry than is usually given in textbooks.

TORFKRAFT, F. Bartel. *Berlin, 1913.*

DER WIDERSTAND UND ANTRIEB VON SCHIFFEN, Ing. Rothe. *Berlin, 1912.*

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ANUARIO ESTAFISTICO DE LA REPUBLICA ORIENTAL DEL URUGUAY 1907-1908. vol. 2, pt. 2. *Montevideo, 1911.*

APUNTES DE ZOOGRAFIA PARTE PRIMERA VERTEBRADOS POR SEVERIANO DE OLEA. *Montevideo.*

COMISION DE ESTUDIOS PARA LA PROVISION DE AGUAS AL MUNICIPIO DE MONTEVIDEO. Informe de la Comision. *Montevideo, 1901.*

CONSTITUCION DE LA REPUBLICA ORIENTAL DEL URUGUAY, P. v. Goyena. *Montevideo, 1887.*

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NATIONAL ASSOCIATION OF COTTON MANUFACTURERS. Trans. no. 92. *Boston, 1912.*

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Billings & Spencer Co., *Hartford, Conn.* Automobile forgings and tools, 1912, 78 pp.; dogs and clamps; catalogue of fine tools and specialties, 24 pp.; catalogue of patent improved drop hammers and other forging machinery, 1911, 44 pp.

Bristol Co., *Waterbury, Conn.* Bull. No. 133, recording wattmeters for direct and alternating current, May 1912, 39 pp.; Bull. No. 138, electric time recorder, September 1912, 15 pp.; Bull. No. 139, mechanical time recorder, August 1912, 7 pp.; Bull. No. 1200, Class II, recording thermometers, August 1912, 47 pp.

Burhorn, Edwin Co., *New York.* Cat. "Burhorn" and "Acme" cooling towers, 16 pp.

Cramp, Wm. & Sons, *Philadelphia, Pa.* Cramp's gear bronzes, 1912.

Fawcus Machine Co., *Pittsburgh, Pa.* Cut herringbone gears.

General Electric Co., *Schenectady, N. Y.* Bull. No. A-4036, direct-current exciter panels, October 1912, 8 pp.; Bull. No. A-4037, isolated and small plant switchboards, October 1912, 14 pp.; Bull. No. A-4039, direct-current motor starting and speed regulating rheostats and panels, October 1912, 35 pp.; Bull. No. A-4040, contractors for industrial service, October 1912, 10 pp.; Bull. No. A-4042, aluminum lighting arresters for alternating-current circuits, October 1912, 36 pp.; Bull. No. 4974, current-limiting reactances, October 1912, 6 pp.; Bull. No. 4993, Type RI single-phase motors, October 1912, 15 pp.; Bull. No. 4997, alternating-current switchboard panels, September 1912, 69 pp.

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Johns-Manville Co., *New York.* J-M roofing salesman, November 1912.

North Western Expanded Metal Co., *Chicago, Ill.* Expanded metal construction, December 1912.

Under-Feed Stoker Co. of America, *Chicago, Ill.* Publicity magazine, November 1912.

UNITED ENGINEERING SOCIETY

American Library Association. Bulletin, July 1912. Papers and Proceedings of the Ottawa Conference. *Chicago, 1912.* Gift of W. P. Cutter.

Calculating Circle, Geo. M. Purver. *Brooklyn, N. Y., 1912.* Gift of author.

Intangible Values of Electric Light and Power Companies, Wm. J. Hagenah. Before the Northwest Electric Light and Power Association, September 11, 12, 13, 1912. *1912.* Gift of author.

Intangible Values of Electric Railways and their Determination from Accounts, Wm. J. Hagenah. Before National Electric Railway Association, Chicago, October 8, 1912. *1912.* Gift of author.

Methods for the Analysis of Iron and Steel used in Laboratories of the American Rolling Mill Co., Middletown, O. *Middletown 1912.* Gift of company.

TRADE CATALOGUES

Buffalo Wire Works Co., *Buffalo, N. Y.* Cat. No. 5, 1904, 111 pp.

De Witt Wire Cloth Co., *New York.* Cat. No. 80, 1909, 148 pp.; wire cloth price list and standard gages adopted March 7, 1899 and March 14, 1900 40 pp.; revised list of wire ropes and wire cords, 1911, 11 pp.

Estey Wire Works Co., *New York.* Cat. and price list (wire cloth), No. 20, 63 pp.; Cat. No. 19, wire work, 68 pp.

Liberty Manufacturing Co., *Pittsburgh, Pa.* Circular of boiler tube cleaner, 4 pp.

New Jersey Wire Cloth Co., *Trenton, N. J.* Cat. No. 62, 1911, 45 pp.

Parker Wire Goods Co., *Worcester, Mass.* Cat. No. 3, June 1909, 200 pp.

Wright Wire Co., *Worcester, Mass.* General catalogue of wire, wire fabrics and wire products, 1912, 224 pp.

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INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	CHAIRMAN	CORRESPONDING SECRETARY
Armour Inst. of Tech.	Mar. 9, 1909	G. F. Gebhardt	E. R. Burley, Jr.	H. R. Kuehn
Brooklyn Poly. Inst.	Mar. 9, 1909	W. D. Ennis	B. L. Huestis	A. Bielek
Columbia University	Nov. 9, 1909	Chas. E. Lucke	E. M. Stone	E. A. Jareckie
Cornell University	Dec. 4, 1908	R. C. Carpenter	S. D. Mills	D. S. Wegg, Jr.
Lehigh University	June 2, 1911	P. B. de Schweinitz	E. E. Finn	J. F. Beers, Jr.
LelandStanfordJr.Univ.	Mar. 9, 1909	W. F. Durand	C. W. Scholefield	V. W. Winters
Mass. Inst. of Tech.	Nov. 9, 1909	E. F. Miller	J. G. Russell	J. B. Farwell
New York University	Nov. 9, 1909	C. E. Houghton		
Ohio State University	Jan.10, 1911	Wm. T. Magruder	R. H. Neilan	R. M. Powell
Penna. State College	Nov. 9, 1909	J. P. Jackson	J. F. Blank	G. W. Barger
Purdue University	Mar. 9, 1909	G. A. Young	A. W. Kimmel	G. F. Lynde
Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	E. Kneass	R. F. Fox
State Univ. of Ky.	Jan.10, 1911	F. P. Anderson	R. R. Taliaferro	F. J. Forsyth
Stevens Inst. of Tech.	Dec. 4, 1908	Alex.C. Humphreys	J. H. Vander Veer	J. Strauss
Syracuse University	Dec. 3, 1912	W. E. Ninde	O. W. Sanderson	R. A. Sherwood
Univ. of Arkansas	Apr.12, 1910	B. N. Wilson	M. McGill	C. Bethel
Univ. of California	Feb.13, 1912	Joseph N. Le Conte	J. F. Ball	G. H. Hagar
Univ. of Cincinnati	Nov. 9, 1909	J. T. Faig	C. W. Lytle	A. O. Hurxthal
Univ. of Illinois	Nov. 9, 1909	W. F. M. Goss	L. G. Smith	C. A. Schoessel
University of Kansas	Mar. 9, 1909	F. W. Sibley	E. A.VanHouten	L. E. Knerr
Univ. of Maine	Feb. 8, 1910	Arthur C. Jewett	E. H. Bigelow	O. H. Davis
Univ. of Missouri	Dec. 7, 1909	H. Wade Hibbard	F. I. Kemp	R. Runge
Univ. of Nebraska	Dec. 7, 1909	J. D. Hoffman	P. S. Toney	M. C. Evans
Univ. of Wisconsin	Nov. 9, 1909	A. G. Christie	W. D. Moyer	W. K. Fitch
Washington University	Mar.10,1911	E. L. Ohle	D. Southerland	A. Schleiffarth
Yale University	Oct.11, 1910	L. P. Breckenridge	C. E. Booth	O. D. Covell

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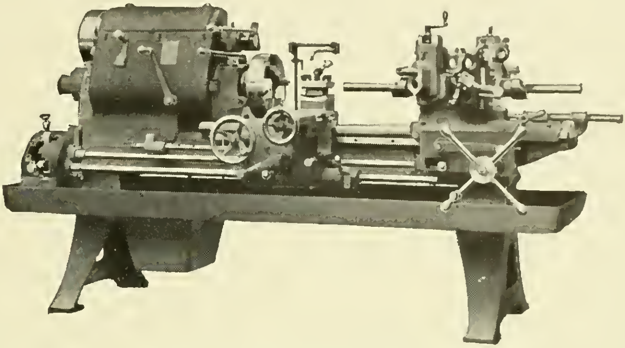

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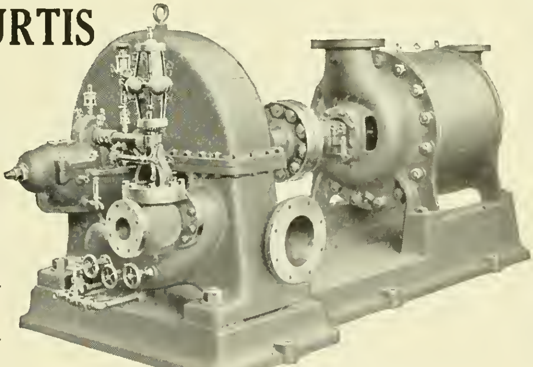

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HARTNESS FLAT TURRET LATHE

Turret Description

THE turret is a flat circular plate; it is mounted on a low carriage containing controlling mechanism. The connections of the turret to the carriage, and the carriage to the lathe bed, are the most direct and rigid, affording absolute control of the cutting tools. The turret is accurately surfaced to its seat on the carriage by scraping, and securely held down on that seat by an annular gib. In the same manner the carriage is fitted to the Vs of the bed; the gibs pass under the outside edge of the bed.

The index pin is located directly under the working tool and so close to it that there can be no lost motion between the tool and the locking pin. The turret is turned automatically to each position the instant the tool clears the work on its backward travel, and it is so arranged that by raising and lowering trip screws near the center of the turret, it may be turned to three, four or five of the six places without making any other stops.

A simple, accurate stop mechanism for the turret slide provides twelve independently adjustable stops, two for each of the six positions of the turret, or any other division required by the operator.

The *feeding mechanism* for the turret slide and the cross-feeding head receives its power through a speed-varying device which is under the convenient control of the hand wheel at head end of bed. One revolution of this wheel gives the full range of feeds, from drilling feed of 120-per-inch to coarse turning feed of 10-per-inch, and every intermediate feed.

A spring torc weighing device on the feed rod gives the pulling power of this feed mechanism a known value. This device yields at a certain predetermined pressure.

In operation the carriage is fed forward until it reaches one of the stops, against which it is held by this pressure

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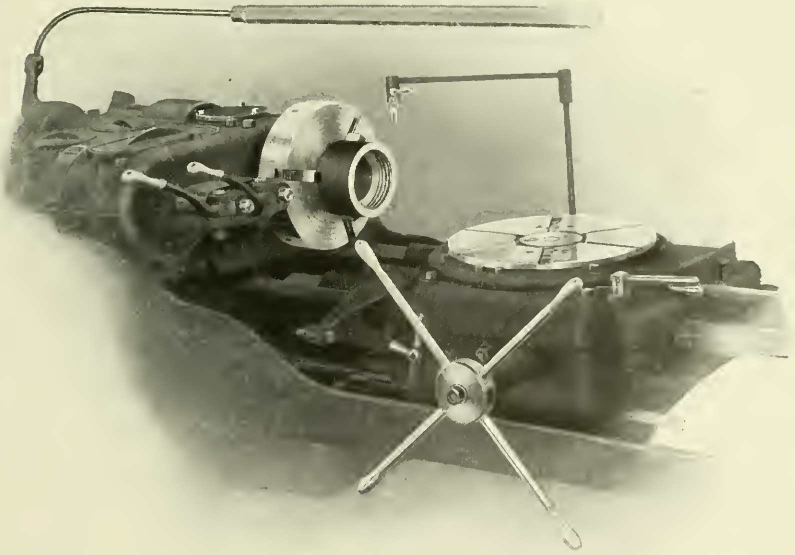
till disengaged by the operator. Arresting the feed without releasing the carriage gives the tool a chance to accurately face the shoulder, leaving a smooth surface instead of the ragged face left when carriage is released under full cut.

It has been the practice heretofore to arrange the positive stop a thirty-second of an inch beyond the knock-off for the feed, and in the usual operation of a machine of this kind the feed knocks off, and then the turret slide, released, jumps back, and the tool digs in, cutting a slight groove just back of the shoulder. When on work requiring exact shoulder distances or smoothly-finished shoulders, the operator brings the slide against the positive stop, holding it there with as nearly as possible uniform pressure until the turner has surely faced its full length. In the present machine the turret is always fed against the positive stop and held there with a uniform pressure, insuring the most accurate results for shoulder length.



Extracts from the book of the Hartness Flat Turret Lathe. Copies of the book mailed on request.

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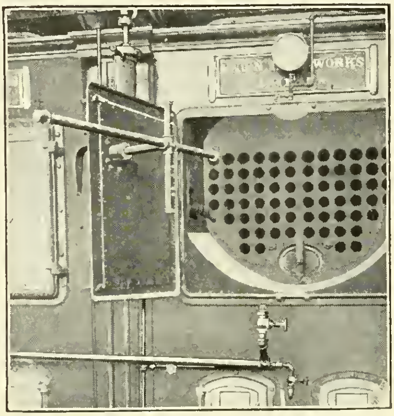

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For Fire Tube Boilers

This blower has been on the market for two years and has been proven a splendid success. Marine Boilers *had* to be blown from the front end. Our "Diamond" System of blowing against the draft *from within the tight-shut boiler doors* proved so perfectly successful on Marine Boilers that we decided to adapt it to Stationary Fire Tube Boilers. The Model "E" here shown is the result; and it has proven a most efficient and popular blower. Write for special circular describing the "Diamond" Model "E."

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1—How Soot in the Boiler tubes has been wasting *your money.*

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3—That you can save more than the cost of the "Diamond" Soot Blower in one season.

Do you realize that the coating of soot which accumulates on boiler tubes offers 140 times more resistance to the transmission of heat than the metal of which the boiler tubes are made?

Do you realize that *Soot* offers 5 times more resistance to heat than *Asbestos* does?

You'd be considered stark, staring crazy if you put a 1-inch wrapping of asbestos around your boiler tubes, yet more heat would be transmitted through it than through a coating of Soot 1-5 as thick.

How thick is the soot on your boiler tubes right now?

"DIAMOND" SOOT-BLOWER SYSTEMS

make it not only possible, but *easy* to keep boiler tubes *absolutely free from soot.* They *keep* Soot off the boiler heating surfaces by a positive mechanical action—4 or 5 minutes 4 times a day as against 45 minutes required by the old hand method to *half* clean them *once.* And scientific tests have proved beyond a doubt that frequent cleaning saves 10% more than the "once a day" method.

"Diamond" Soot Blowers are saving money on *all standard types of boilers* —20,000 of them—and the Front End Model "E" illustrated here is making good in hundreds of installations.

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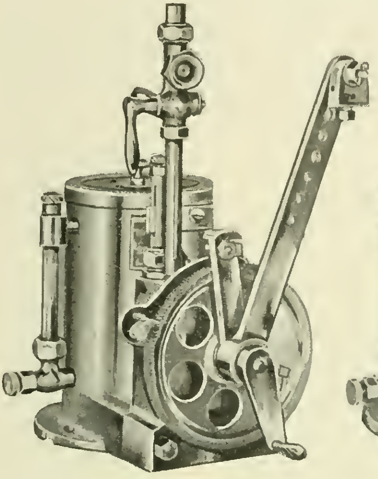

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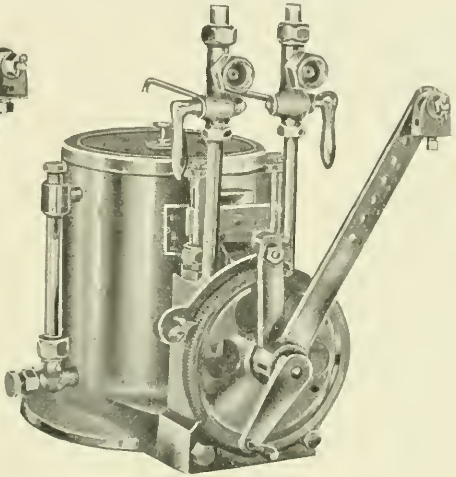

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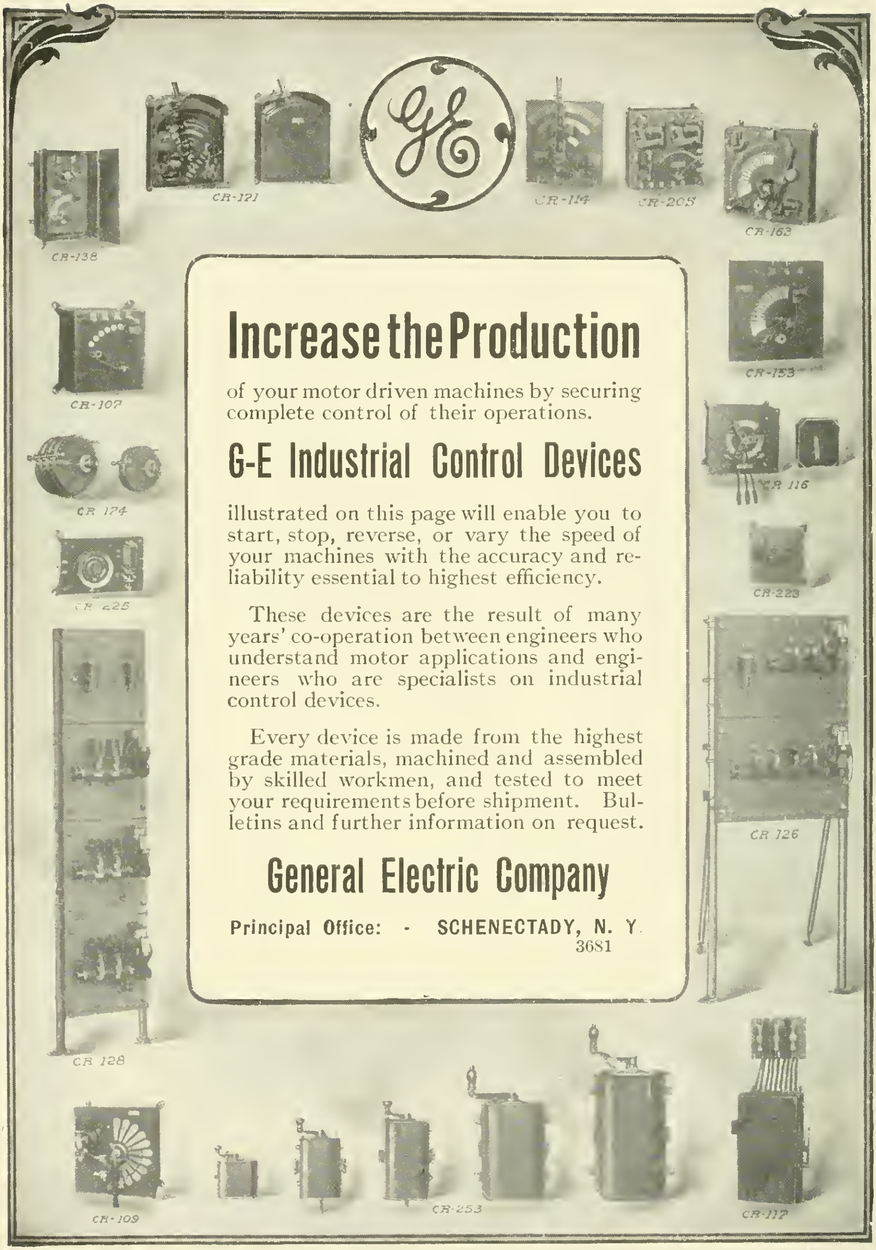

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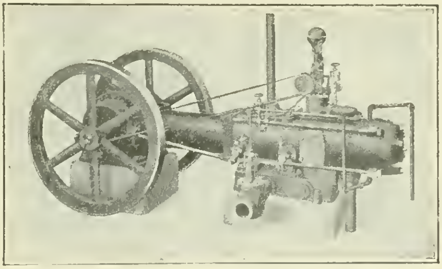

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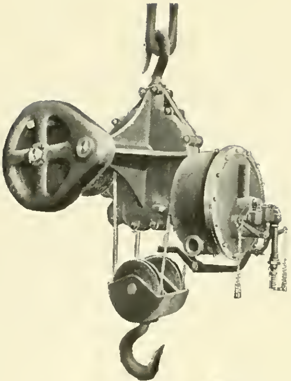

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Bulletin 8006

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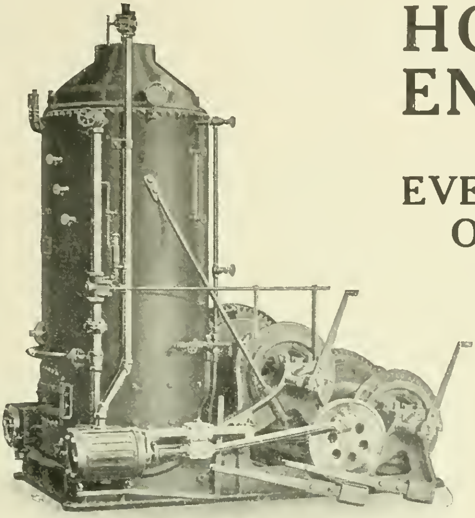

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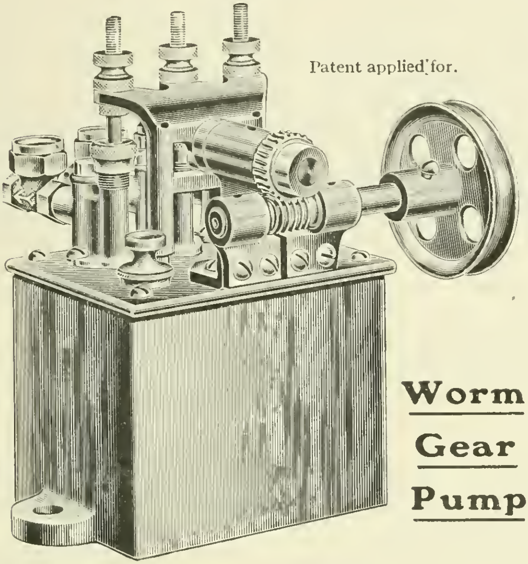

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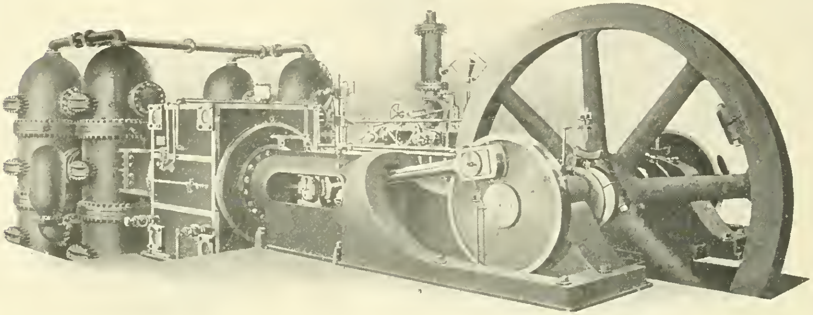

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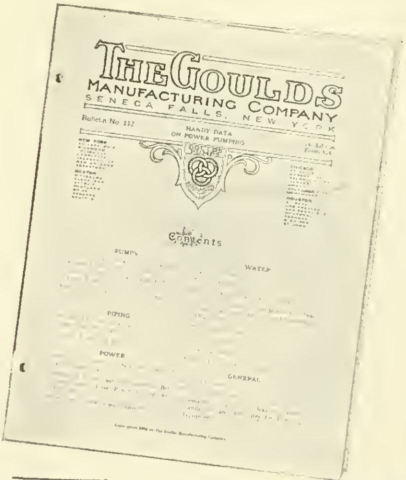

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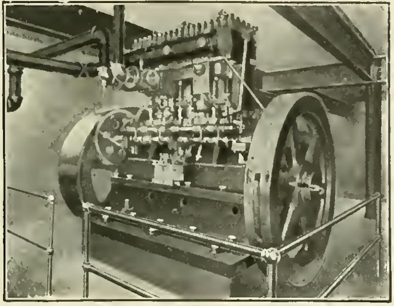

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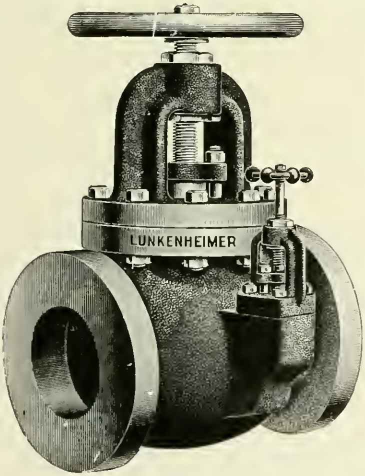

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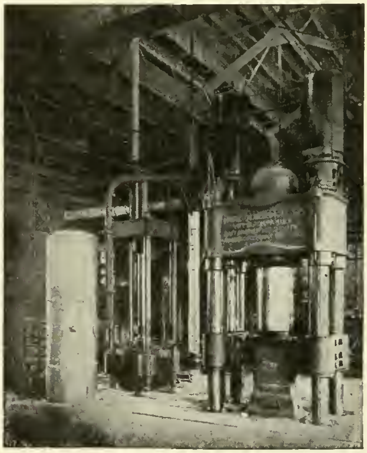

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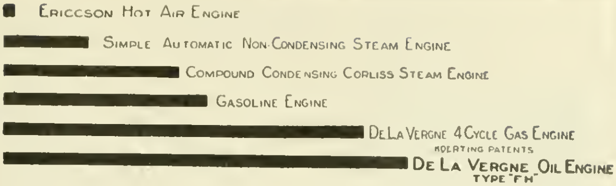

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The **fuel consumption** of an engine depends on two factors—its **mechanical efficiency and its thermal efficiency.**

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The diagram above indicates the thermal efficiency of the De La Vergne type "FH" oil engine in comparison with the thermal efficiencies of various other heat engines. The lengths of the respective bars represent the highest thermal efficiency (referred to delivered horse-power) reported by various authorities for the different engines.

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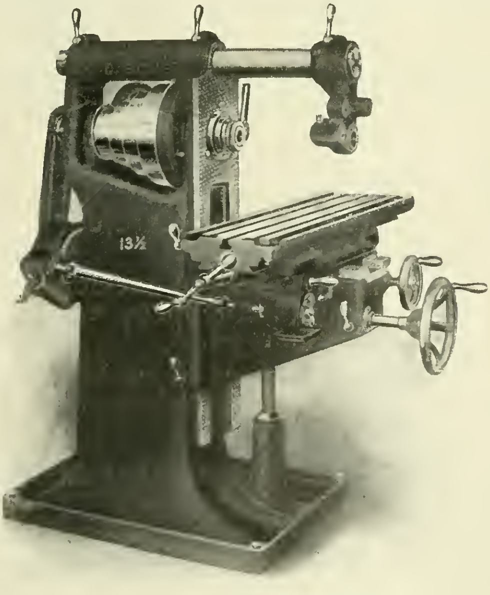

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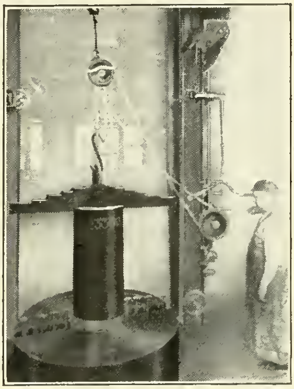

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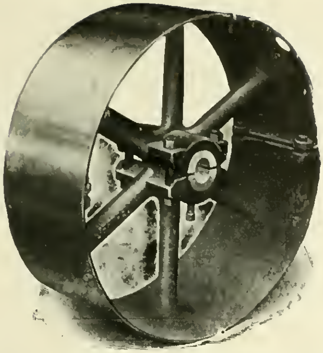

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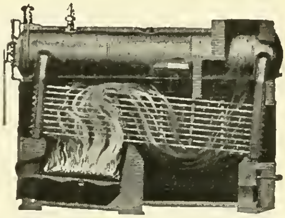

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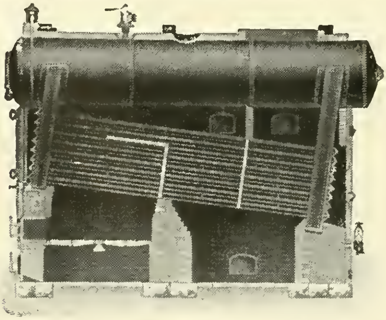

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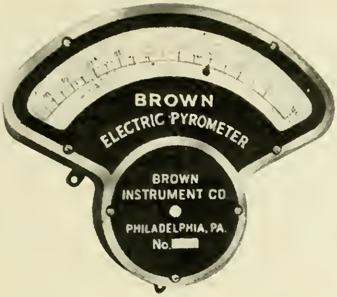

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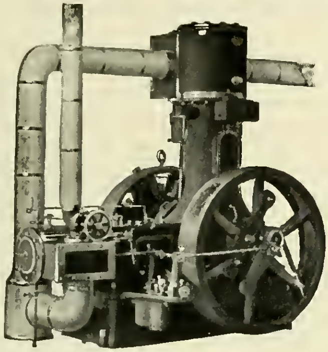

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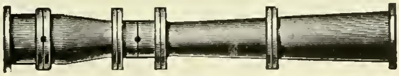

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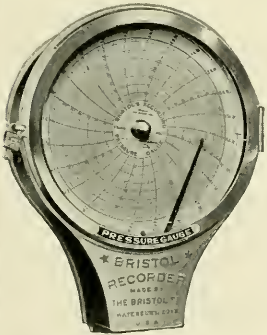

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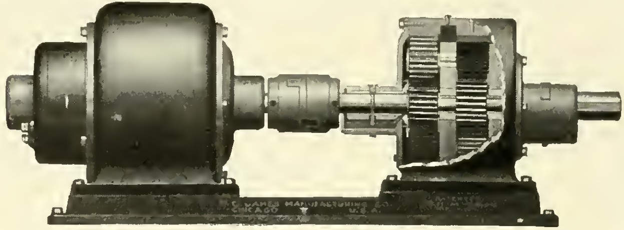

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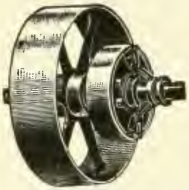

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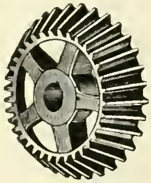

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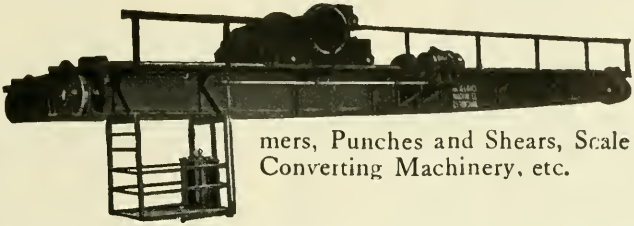

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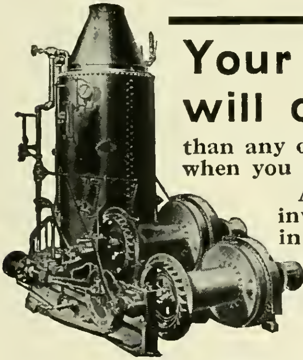

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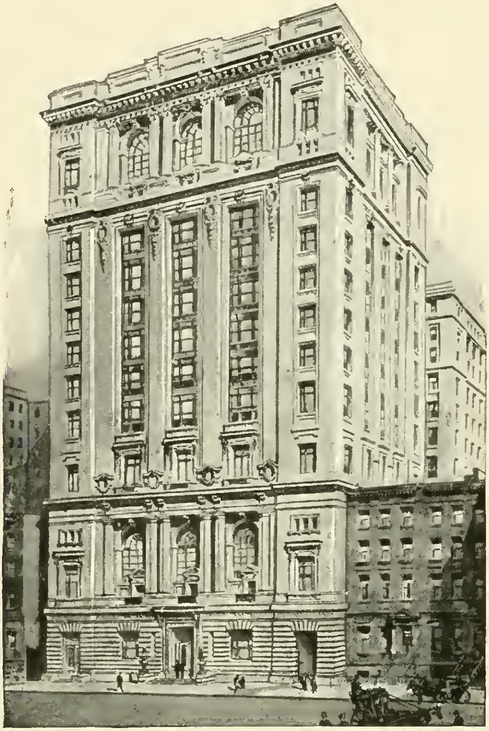

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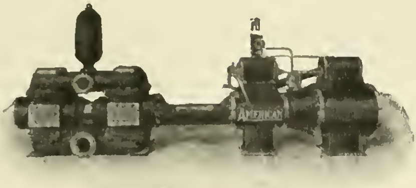

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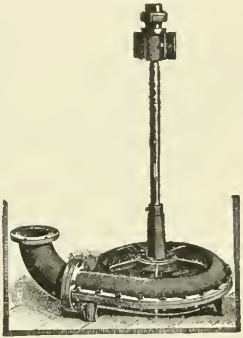

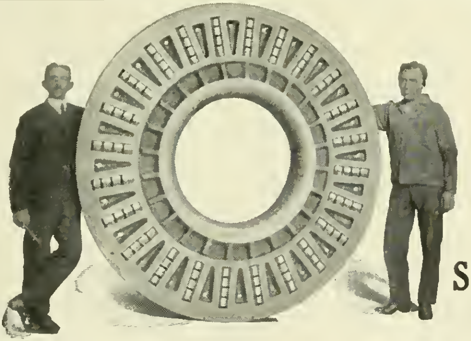

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THE
JOURNAL
of
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

FEBRUARY 1913

35 CENTS A COPY $3 A YEAR

MONTHLY MEETINGS: PHILADELPHIA, FEBRUARY 8; NEW YORK, FEBRUARY 11; BOSTON, FEBRUARY 25; NEW HAVEN, APRIL 16; SPRING MEETING: BALTIMORE, MAY 20–23; MEETING IN GERMANY: JUNE 21–JULY 7

APPLICATIONS FOR MEMBERSHIP SHOULD BE FILED AT ONCE

The next election of members will take place at the Spring Meeting which will be held at Baltimore, May 20–23. The ballot for that election will close on February 15.

As a result of the activities of this Committee the number of applications received in 1912 was 100 per cent greater than in 1911, and at the same time the standard of membership has been put on a higher plane than ever before by the strictness of the Committee on Membership in their interpretation of the requirements.

It is hoped that every member will coöperate with the Committee on Increase of Membership by endeavoring to secure applications from those whom he deems especially qualified for admission to membership in the Society.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chairman*

COMING MEETINGS OF THE SOCIETY

February 8, *Philadelphia, Pa.*, Engineers Club. Paper: Overhead Expense Distribution, Royal R. Keely.

February 11, *New York City*, Engineering Societies Building. Paper: Port Facilities for Ships and Cargoes in the United States, by Wm. T. Donnelly, Consulting Engineer. Illustrated with lantern slides. Informal dinner, 6.30 p. m., 4 W. 40th St., $1.25 per plate. Kindly notify H. R. Cobleigh, 505 Pearl St., before noon, February 10, of your intention to participate. Meet in Society's rooms, 6.15 p. m.

February 25, *Boston, Mass.* Subject to be announced.

April 16, *New Haven, Conn.* Mason Laboratory, Yale University. Subject for afternoon session: Factory Heating; for evening session, Factory Lighting.

May 20–23, *Baltimore, Md.*, Spring Meeting. Headquarters, Hotel Belvedere.

June 21–*July* 7, Joint Meeting with Verein deutscher Ingenieure, Leipzig and various industrial cities of Germany. See page 3 for further details.

FEBRUARY 1913 VOL 35 No. 2

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39th STREET . . . NEW YORK

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Price, 25 cents a copy, or $2 a year, to members and affiliates of the Society; 35 cents a copy or $3 a year to all others. Postage to Canada, 50 cents additional; to foreign countries, $1 additional.
Entered as second-class matter, January 4, 1912, at the Postoffice, New York, N. Y., under the act of March 3, 1879.

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THE JOURNAL

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THE AMERICAN SOCIETY OF
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MEETING IN GERMANY, 1913

Our hosts, the Verein deutscher Ingenieure, have advised us that since the meeting in Leipzig will occur during the summer vacation season, when the hotel accommodations will be strained to the utmost, and also in view of the difficulties of conducting large groups through industrial establishments, our official party must be limited to two hundred members and one hundred ladies. Notwithstanding this limitation, it has been the experience of the Society on similar occasions that all who actually go will in all probability be included in the official party.

The Committee on Arrangements have been able to secure from the Hamburg-American Line a discount of 5 per cent from the regular tariff on bookings made for the official S.S. Victoria Luise, where such discount will not bring the net price below the fixed minimum, and for the return passage a discount of 20 per cent from the regular tariff to those who return by this line previous to August 1, 1913, provided that the net price does not fall below the fixed minimum rates. At the present time the Hamburg-American Line estimate that the total cost of the official land trip through Germany, commencing at Hamburg, June 21, and concluding at Munich, July 7, will be approximately $80 per person. The Committee on Arrangements have not agreed on a definite figure as yet and are now awaiting a further proposal from the company.

The estimated possible minimum cost of the entire trip is as follows:

Outgoing voyage on S.S. Victoria Luise	$97.50 Minimum
Official Trip through Germany to Munich, approx	80.00
Second Class ticket from Munich to Hamburg	10.90
Return voyage on Hamburg-American Line, estimated	100.00
	$288.40

The reductions will hold under conditions stated above for return trip on the following steamers of the Hamburg-American Line:

To New York:	
Kaiserin Auguste Victoria, sailing Thursday, July 17, Min. Rate	$115.00
Imperator, sailing Wednesday, July 30, Min. Rate	130.00
To Boston:	
Cleveland, sailing Thursday, July 10, Min. Rate	97.50
Cincinnati, sailing Tuesday, July 29, Min. Rate	97.50

All reservations should be made direct with the Hamburg-American Line. Branch offices are located in the following cities: San Francisco, Boston, Philadelphia, Chicago, St. Louis and Pittsburgh. No other than the principal and the above branch offices may take reservations as this is a special steamer at special rates for our party. Those of the party who take outgoing passage on the Victoria Luise assume no obligation in connection with their return passage, but owing to the common desire of most American travelers to return at approximately the same time it is advisable that all secure their return voyage accomodations on some line at the time of making bookings for the outgoing trip.

Attention is drawn to the fact that although we are obliged at present to limit the number of the party which may participate in the official events in Germany, any number of members and friends may accompany the party on the trip over. The Victoria Luise will accommodate about 450 cabin passengers, and it is strongly urged that the entire vessel be occupied by the Society and its friends. The Committee consider as members of the official party to date only those who have either advised the Committee that they will join the official party in Europe or who have actually taken accommodations on the official steamer. Applications will be registered in the order of their receipt at the headquarters of the Society. When the prescribed limit has been reached, any vacancies which may occur in the party will be filled in the order of the receipt of requests.

Under these circumstances, the Committee on Arrangements, E. D. Meier, Chairman, have been obliged to urge the members to make a definite statement of their intention to join the party, not later than February 1, 1913.

OFFICERS BOOKED TO SAIL ON THE VICTORIA LUISE OR INTENDING TO JOIN THE PARTY

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Geo. M. Bond
L. P. Breckenridge
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S. T. Wellman
W. H. Wiley

Note.—About seventy ladies are also included in the official party.

THE SPRING MEETING

The members may look forward with anticipation to the coming Spring Meeting, to be held in Baltimore, May 20-23. This will be the first visit of the Society to this city and the cordiality of the invitation received from the members resident there, as well as the Engineers Club and the civic organizations, is evidenced by the fact that it was extended two years in advance of the date for the meeting.

The technical sessions have already been tentatively determined by the Committee on Meetings, and at a meeting of the Baltimore members, the Engineers Club and the civic organizations, held in Baltimore on December 19 and attended by the Secretary, the general scheme of social features was discussed. The Chairman of the Local Committee will be Layton F. Smith, past-president of the Baltimore Engineers Club.

Baltimore with its remarkable harbor and its nearness to Washington and Annapolis is a most attractive city in which to hold a convention, and the membership are assured of adequate and comfortable accommodations at the Hotel Belvedere, the headquarters selected. More than three hundred rooms are available and the hotel is most conveniently arranged in respect to meeting halls, accessibility, etc. As the date of the meeting comes within the height of the season in Baltimore, when the weather is ideal and the city is crowded with visitors, hotel accommodations should be reserved in advance and as early as possible, in order to insure against disappointment.

One of the excursions which will be included in the program laid out by the local committee will be a trip to Annapolis, one of the oldest cities in America, and hence of historical as well as patriotic interest. The trip will probably be made by boat, and the visitors will have an opportunity to see the grounds and buildings, on which fifteen million dollars have recently been expended, and to watch the midshipmen in various naval manoeuvres.

There will also be excursions to the hydroelectric plant at McCalls Ferry on the Susquehanna River, and to the various points of interest in Baltimore itself, such as the new sewerage disposal plant recently installed at an expense of twenty million dollars, the new system of municipal docks, as well as its principal industries, including sealing devices, canning and preserving, and tobacco.

CURRENT AFFAIRS OF THE SOCIETY

At a recent meeting of the Council the following were elected members of the Executive Committee for 1913: W. F. M. Goss, Chairman, Alex. C. Humphreys, Vice-Chairman, E. B. Katte, E. D. Meier, and George A. Orrok. Committee appointments were also announced as follows: Finance Committee, R. M. Dixon; Committee on Meetings, R. H. Fernald; Publication Committee, F. R. Low; Membership Committee, L. R. Pomeroy; Library Committee, serving on the Library Board of the United Engineering Society, Chas. L. Clarke, Alfred Noble, E. Gybbon Spilsbury, Leonard Waldo, Calvin W. Rice; House Committee, F. A. Scheffler; Research Committee, L. S. Marks, R. D. Mershon: Public Relations, George M. Brill.

LOCAL COMMITTEES

Committees have been chosen in the several cities where meetings are held at stated intervals, and the work outlined for the year in these various centers. In Boston, the following committee were elected at a recent meeting: Henry Bartlett, R. E. Curtis, H. N. Davis, W. G. Snow, A. L. Williston; in New York, the committee chosen consists of, F. A. Waldron, Chairman, Edward Van Winkle, Secretary, R. V. Wright, Treasurer, H. R. Cobleigh, and J. J. Swan. In San Francisco, W. F. Durand, T. W. Ransom, C. R. Weymouth, and R. S. Moore, are the committee chosen for the arrangements for the International Engineering Congress in 1915, preparations for which are now in progress.

COMMITTEE ON STANDARDS

The Committee on Myriawatt, H. G. Stott, A. F. Ganz and Carl Schwartz, which has recently coöperated with the American Institute of Electrical Engineers on this important question, is to be continued as a Committee on Standards, with a view to coöperating with this same organization in matters of mutual interest and importance. The conclusions reached on the subject of the myriawatt are published in this issue of The Journal.

Calvin W. Rice, *Secretary.*

LIBRARY SEARCHES

An important work being done in the Engineering Societies Library is in the conduct of engineering searches, and information is available on a large number of subjects. These include, among many, lubricants and their testing; gears, skew bevel, helical and spiral; burners for liquid and gaseous fuels; kerosene and other oils used in gasolene engines; spring motors; gasolene-electric vehicles; electric welding; transportation of materials in manufacturing plants; luminator process of boiler feedwater treatment, etc.

As an example of the speed and thoroughness with which these searches are made, a member of the Society recently solicited a complete description of the various universities of the world, and received within a week 169 photographs, descriptions, etc., at a total expense of $47. In this search a delay of two days was caused by an accident on the part of the firm furnishing the photographs.

Searches which are on file in the Library may be obtained by paying the small cost involved in copying, and information as to new searches may be secured on application to the Librarian.

The members of the Society are invited by the American Institute of Electrical Engineers to attend the lectures.

STANDARDIZATION OF THE MYRIAWATT

At a joint meeting of the Society's Special Committee on Myriawatt with the Standards Committee of the American Institute of Electrical Engineers on December 23, 1912, the following resolutions were adopted after a very full discussion:

Whereas, the "myrowatt" or "myriawatt" was suggested as a convenient unit of power only 2 per cent larger than the most recently determined values of the "boiler horsepower," and

Whereas, a paper setting forth the advantages of the use of the "myriawatt" as a unit of power in dealing with the performance of steam boilers, steam engines, gas engines, steam and water turbines, was read before the annual convention of the American Institute of Electrical Engineers in Boston in June 1912, was discussed and was published in the Proceedings of the Institute, and

Whereas, The American Society of Mechanical Engineers has appointed a special committee to confer with the Standards Committee of the American Institute of Electrical Engineers upon this unit, as presented in the said paper,

Be it Resolved, (1) That the two committees in joint session recommend in their respective societies the use of the "myriawatt" as unit of thermal or mechanical power, as indicated in the above-mentioned paper; and

(2) That the two committees also jointly recommend to their respective societies the exclusive use of the myriawatt in connection with boilers, producers, turbines and engines, and discontinue the use of the term "boiler horsepower."

The paper to which the committee refer is reprinted herewith from the Proceedings, through the courtesy of the American Institute of Electrical Engineers.

THE MYRIAWATT

By H. G. Stott and Haylett O'Neill

The object of this communication is to introduce a new unit of power which, if adopted, will afford a basis of comparison of all converters of energy, thermal and mechanical; and also will be international in its character, as it is merely a new multiple of the watt.

In American and European practice, at the present time, there are in use many empirical units, the use of any one of which is restricted to a distinct territory. A few of the more important ones are, horsepower, boiler horsepower, kilowatt, cheval à vapeur, pferde-kraft and poncelet. Obviously an engineer in attempting to compare data from a foreign country, is compelled to face a confusion of terms, which usually can be made intelligible only by laborious calculations.

Again, in the United States there are in vogue such units as boiler horsepower and horsepower, which, while similar in sound, have no logical connection; and one has yet to find where the "horse" comes in.

With the rapid development in electrical measuring instruments, and, until recently, a corresponding lack of development in steam-flow measuring instruments, the term kilowatt has become more and more used as the one unit of power output.

The term became a necessity with the growing favor of steam turbines, and all direct-connected units where it is impossible to measure accurately the mechanical and the electrical power separately.

To form a connection between the boiler or producer output, the engine and generator output, the term "myriawatt," derived from the Greek "myria," meaning ten thousand, and the term watt, is proposed.

For the purpose of standardization, the British thermal unit, 1/180 of the heat required to raise one pound of water from 32 deg. fahr. to 212 deg. fahr. and the equivalent evaporation from and at 212 deg. fahr. (970.4 b.t.u.) is used (Marks and Davis).

From this, the following equivalents are obtained:

1 foot-pound = 0.001286 b.t.u.
1 kilogram-meter = 0.009302 b.t.u.
1 gram-calorie = 0.0039683 b.t.u.
1 horsepower = 2547 b.t.u. per hr.
1 cheval à vapeur = 2512 b.t.u. per hr.
1 pferde-kraft = 2512 b.t.u. per hr.
1 poncelet = 3349 b.t.u. per hr.
1 kilowatt = 3415 b.t.u. per hr.
1 boiler horsepower = 33479 b.t.u. per hr.
1 myriawatt = 34150 b.t.u. per hr.

Reduction of the myriawatt to the above units

1 mw. = 34,150 b.t.u. per hr.
1 mw. = 8,605,000 gram-calories per hr.
1 mw. = 26,552,000 foot-pounds per hr.
1 mw. = 3,670,900 kilogram-meters per hr.
1 mw. = 13.410 horsepower
1 mw. = 13.597 cheval à vapeur
1 mw. = 13.597 pferde-kraft
1 mw. = 10.197 poncelets.
1 mw. = 10 kilowatts.
1 mw. = 1.020 boiler horsepower

Reduction of all the above units to myriawatts or myriawatt-hr.

1 b.t.u. = 2.928×10^{-5} mw-hr.
1 gram-calorie = 1.1621×10^{-7} mw-hr.
1 foot-pound = 3.7662×10^{-8} mw-hr.
1 kilogram-meter = 2.7238×10^{-7} mw-hr.
1 horsepower = 7.457×10^{-2} mw.
1 cheval à vapeur = 7.354×10^{-2} mw.
1 pferde-kraft = 7.354×10^{-2} mw.
1 poncelet = 9.807×10^{-2} mw.
1 kilowatt = 1.00000×10^{-1} mw.
1 boiler horsepower = 9.804×10^{-1} mw.

The last two are practically the same, differing by only two per cent. The usual practice is to rate water-tube boilers on the basis of one boiler horsepower per 10 sq. ft. of heating surface.

With modern plants, notably those in marine service, operating from two to five times this rating, the ordinary method of determining nominal boiler capacity could be stretched 2 per cent without materially affecting the present rating: i.e., the boiler might be rated at 34,150 b.t.u. per hour for each 10 sq. ft. of heating surface, instead of at 33,479 b.t.u. per hour for each 10 sq. ft. of heating surface.

The myriawatt as a unit of boiler or producer output, and correspondingly a unit of input to all kinds of dynamical machinery, is fixed in value by the watt, and by its very sound gives a clue to its meaning.

To compare efficiencies of direct-connected units and eliminate the various factors of quality of steam, pressure and vacuum, the term " b.t.u. per kilowatt-hour " has been used. If we used the term myriawatt

$$\text{per cent overall efficiency} = \frac{10 \times \text{kilowatts output}}{\text{myriawatts input}}$$

Also, with the thermal efficiency of the engine known, the heating surface in the boiler room is determined (assuming the 10 sq. ft. rule), thus, two kilowatts per myriawatt input to an engine is equivalent to 20 per cent thermal efficiency of the engine and the heating surface in the boiler room equals kilowatts engine output $\times$ 10/2.

Obtaining an exact figure of the same with the boiler horsepower unit involves a tedious operation.

The efficiency of internal combustion engine-driven units of all cycles, such as Diesel, Brayton, Otto, etc., is determined by rating the heating value of the fuel in myriawatts; thus

$$\text{per cent efficiency} = 10 \times \frac{\text{kilowatts output}}{\text{myriawatts input}}$$

With hydraulic machinery, again rating the water power input to the wheels in myriawatts:

$$\text{per cent efficiency} = 10 \times \frac{\text{kilowatts output}}{\text{myriawatts input}}$$

Thus, in the term myriawatt lies a simple, logical and universal means of comparing outputs and inputs of all classes of energy converters, the meaning of which will be clear to all engineers wherever a piece of electrical machinery is to be found.

Comparisons in Efficiencies and Rates of Output With Various Types of Energy Converters, in Terms of the Myriawatt

1 Boiler output:

Nominal rating = 600 boiler h.p.

Total draft head inches water gage	Boiler h.p.	Myriawatts
1.730	1375	1348

2 5000-kw. engine:

Kw. output	$\frac{\text{Lb. steam}}{\text{kw-hr.}}$	$\frac{\text{b. t. u.}}{\text{kw-hr.}}$	$\frac{\text{Kw. output}}{\text{Mw. input}}$	Per cent thermal efficiency overall
4977	17.2	20,160	1.70	17

3 5500-kw. high-pressure turbine:

Kw. output	$\frac{\text{Lb. steam}}{\text{kw-hr.}}$	$\frac{\text{b. t. u.}}{\text{kw-hr.}}$	$\frac{\text{Kw. output}}{\text{Mw. input}}$	Per cent thermal efficiency overall
8183	16.39	18,450	1.85	18.5

4 15,000-kw. engine—low-pressure turbine:

Kw. output	$\frac{\text{Lb. steam}}{\text{kw-hr.}}$	$\frac{\text{b. t. u.}}{\text{kw-hr.}}$	$\frac{\text{Kw. output}}{\text{Mw. input}}$	Per cent thermal efficiency overall
11,240	13.19	15,660	2.18	21.8

5 56-in. low head water-turbine:

Brake h.p.	Brake kw.	$\frac{\text{Kw. output}}{\text{Mw. input}}$	Conversion eff. per cent overall
283	211	8.41	84.1

6 Steam plant efficiency:

Lb. coal per kw-hr. = 2

b.t.u. per lb. coal = 14,250

b.t.u. per kw-hr. = 28,500

Kilowatts per myriawatt input to boilers = 1.2

Plant efficiency = 12 per cent

7 Gas power plant efficiency:

Kw. output	$\frac{\text{Cu. ft. gas}}{\text{kw-hr.}}$	$\frac{\text{b. t. u.}}{\text{kw-hr.}}$	$\frac{\text{Kw. output}}{\text{Mw. input}}$	Per cent thermal efficiency overall
5200	145	14,220	2.4	24

DEVELOPMENTS IN MACHINE SHOP PRACTICE DURING THE LAST DECADE

REPORT OF SUB-COMMITTEE ON MACHINE SHOP PRACTICE

In this report the principal improvements in machine shop practice developed approximately during the last ten years are reviewed. The reason for presenting an extended review now, is that the sub-committee on machine shop practice should record the advances made each year, but in the present case the committee having been only recently organized, there exists in the Society's proceedings no consecutive account of progress. To carry the record back to a logical date, that of the report made by Fred J. Miller to the Bureau of the Census, in 1905, is mentioned but, of course, the actual date is somewhat indefinite.

2 The review is incomplete because of the limitation of time to prepare it, and because of a natural diversity of opinion as to the limitations of what should properly be considered machine shop practice. If this review has included matters generally regarded outside of the limitations, it may be considered that the larger field was included because of practical difficulties in drawing a well-defined line between machine shop practice as such and machine design, administration, heat treatment of steel and other factors affecting production. To ignore them is impossible. The operation of metal-working tools and their productive capacity are as much matters of machine design, arrangement and management as of individual skill. In fact, productive capacity in the past depended very largely on the skill and initiative of the workman, but now the rate of production in many branches of manufacture is almost entirely governed by the construction of machines, so that the designer, when viewed in this light, is closely allied with shop practice.

Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers.

"The transference of skill" by the machine designer from the operators to the machines has embodied in the latter much of the accumulated experience of many mechanics working on simpler and more primitive tools. So it may be asserted that much of the improvement in machine shop practice has appeared in the improvement of machine tools themselves in one way or another.

3 *Variety of Machine Shop Practice.* When it is considered that machine shop practice embraces a very wide variety of work, ranging from the smallest to the largest manufactured products, and all kinds of repair work, the difficulty of classifying and differentiating it can be appreciated. Locomotive repair work, for example, is in a class by itself in which peculiar methods have been developed, differing radically from those followed in doing similar work in other lines. The slotter, for example, is a machine tool in high favor in railroad shops and, outside of shipyards, has been little used elsewhere. It is, however, slowly coming into use in manufacturing works. The milling machine until a few years ago had not gained a foothold in railroad repair shops, largely because it was and still is not as well adapted to handle the general run of plane finishing required in these shops as the planer and shaper. The latter are adaptable machines peculiarly suited to non-repetitive operations, while the milling machine excels in manufacturing.

4 *Increased Weight of Machines.* One of the noticeable changes in machine shop equipment during the past ten years, is the increased weight and power of machine tools, which was made necessary through the general application of high-speed steel cutting tools. While the increased capacity of machines which followed in the wake of the application of high-speed steel was directly instrumental in bringing about such increases in the weight of machines, the result has been beneficial, not only in increased production but in accuracy of product, because of greater rigidity and consequent better preservation of alignment.

5 *Foundations.* Progress has also been made in the methods of erecting machinery. With large size machines the foundation plays a most important part in the accuracy of the work produced. For instance, the provision of a massive, well-built foundation for large planers is imperative. When not provided,

the weight of the machine and work must inevitably cause settling and springing out of shape. Every mechanic knows that such a disturbance of the foundation affects the alignment, which means that the work produced on the planer will be inaccurate; the use of leveling plates under the feet of planers to provide uniform support and means for correcting errors of alignment has become general; the elimination of defective action due to want of support, and the increased mass and rigidity have in the case of planers resulted in the production of plane surfaces closely approaching theoretical planes when the work itself affords the necessary rigidity and uniformity of section. Hence, hand scraping to perfect alignment is not as necessary as it was a few years ago, and it may be said that on some classes of work scraping is now largely more of an ornamental than a corrective process. On high grade machines, however, scraping or grinding probably will continue to be necessary to correct inaccuracies of surface and alignment.

6 *Electric Motor Drive.* The subject of electric motor drives was given much prominence in discussions of machine shop practice a few years ago, the bias being generally in favor of individual motor drive. While subsequent experience has shown, that the direct-connected electric motor has certain limitations and disadvantages for some classes of work, it has also shown that the same results and efficiency cannot be obtained with the group system of driving modern designs of machine tools. The investment in motors is less with the group system but the flexibility of the independent drive is lost. When a machine driven by an independent motor is properly equipped for easy handling, increase of production over that of the same machine in a group system is practically insured. One machine tool builder has found it a good rule to apply independent motors wherever the power requirement is 5 hp. or more. Hardened steel gears in the driving train reduce gear troubles to a minimum. When the character of work is constantly changing and new groupings of machines are required from time to time, the individual drive is at great advantage. The machines can then be placed " like men on a checker board."

7 Improvements have been made in the characteristics of variable speed and reversible motors. Automatic controllers have been introduced which make the stopping and starting of

machines simply the matter of pushing a button. These devices protect the motors, save time and protect the machines from shocks.

8 *Automatic Machines.* Progress has been made in the development of automatic and semi-automatic machines for the production of duplicate parts from bar stock, iron and brass castings. Many special fixtures have been designed for automatic screw machines which have widened their scope to include a great variety of small parts on which a number of operations must be performed before cutting off from the bar, such as small spiral gears, capstan screws, etc. The cost of production is so greatly reduced that these machines are generally applied where the quantity of work to be produced warrants the cost of installation and tool maintenance. The scope of other types of automatic machine tools is wide and constantly increasing. Certain examples will be mentioned later. Many pages could be devoted to the improvements in these machines alone without exhausting the topic; but attention is called here to the simplification of equipment required for the manufacture of highly developed specialties because of the possibility of buying the bulk of the parts from screw machine product specialists. A manufacturer of a specialty, can if he chooses, organize on an assembling basis, confining his actual manufacture to the making of a few principal parts. This development is having a marked influence on our export trade.

9 *Training Mechanics.* Modern methods of manufacturing are responsible for limiting the employment of men to specific operations only, and pursuit of the plan is making it hard to secure all-around machinists. Young men come into a factory and soon acquire the necessary skill to become proficient drill press operators or milling machine operators. They are able to earn fairly good wages in a shorter space of time than if they served the necessary term of apprenticeship to become competent all-around machinists. The endeavor has been made in the larger manufacturing cities to offset the narrowing effect of specialized training by the introduction of training schools in which young mechanics are given instruction in the theoretical side of their work. The results obtained by this training are beneficial. Men are acquiring both theoretical and practical knowledge, so that to a limited extent at least, they are obtaining the benefits of a technical education coupled with practical training.

10 *Scientific Management.* One of the noteworthy improvements in modern shop practice is the application of *the principles* of scientific management. While the details and elements that make up the complete system advocated by Mr. Taylor are not widely used in full, undoubtedly the fundamental principles are coming to be more thoroughly understood and are being quite generally applied. Some of the more specific improvements referred to in the following may not be strictly modern, but doubtless most of them can be so classified because they are now common, whereas ten years ago they were found in comparatively few shops.

11 *Standardization of Tool Grinding.* The turning and planing tools in many shops are now ground to standard shapes in the tool-room on special tool grinding machines. This method not only saves the time of the machine tool operator, but insures the grinding of all tools to the correct form and it also saves what is of greater value—the loss of the productive time of the machine tool. The stock of tools required for a shop is also much smaller.

12 *Checking System for Small Tools.* Most shops at the present time keep all small tools in the store-room, except those in actual use. In this way, the tools are kept in good condition and a much smaller stock is required. Not many years ago it was quite common for each workman to have his own stock of tools. Consequently there were good tools and poor tools just in proportion as there are good workmen and bad workmen. For instance, a lathe operator had his own stock of mandrels which were made to suit each particular job, and when necessary one man borrowed from another. The result was that the workmen wasted a great deal of time wandering around looking for mandrels and other auxiliary equipment. It may seem somewhat out of place to refer to this well-known method of handling small tools by a checking system in a paper on modern improvements, because it is an old feature of many shops. This system was not generally employed ten years ago in many of the small and medium sized shops.

13 In some shops in which scientific management has been applied, and where the work in connection with each operation is planned in advance, it is the practice to make up at the time the work is planned, a list of the tools that will be required for the performance of each operation, this list being sent to the tool

room in advance of the time that the tools will be required, and the tools delivered to the workman by a tool carrier, thus saving the time of the workman as well as that of his machine.

14 *Speeds and Feeds.* The important questions of speed and feed in connection with machining operations have, during recent years, been carefully studied by many superintendents and foremen who formerly relied entirely on the judgment of the workmen, which was sometimes good and sometimes bad. Speeds and feeds are fixed in the planning department and are based on the power of the machine and character of the metal.

15 *Tool Selection.* More thought is now given to the selection of machine tools for various classes of work. A few years ago, many shop foremen used a certain type of machine for a given class of work, because that type had always been used for that purpose. It seems that there is much less conservatism today and precedent does not count for as much as it did a few years ago. The tendency is to design the machine for the work instead of adapting the work to the machine equipment.

16 *Inspection of Finished Parts.* Machine parts are now carefully inspected in many shops by an independent inspection department, whereas formerly the only check on the accuracy of machined work was in the erecting department—if everything could be assembled, the work was considered satisfactory. The more exacting requirements of recent years, however, made necessary the general adoption of a rigorous system of inspection. Thorough inspection and testing are necessary features of interchangeable manufacturing methods; tools and system have become highly specialized. In the manufacture of firearms and other high-grade products from fifty to one hundred separate tests or gagings on a single part are not uncommon.

17 In some shops doing work of a miscellaneous character, it is the practice to have an inspector go to the machine at the time a job is started to make sure that the workman understands all of the requirements with reference to the quality required in the work that he is to do. instructing the workman as to the degree of accuracy required, the kind of finish, etc., and seeing that he does not make a mistake in reading his drawing, setting his measuring tools, etc. The inspector inspects the work done in the operation in question upon the first piece where there are several pieces to be done, thus avoiding the danger of an error on the first piece being repeated on all subsequent pieces. An

inspection is also made upon the completion of each operation of the work done on all pieces in the lot for the purpose of detecting any error that may have been made, so that steps may be taken for its correction without delay.

18 *Cooling Lubricants.* Another improvement in shop practice worthy of mention is the more generous use of cooling mediums on cutting tools, and the provision of distribution systems for both the tools and the bearings supplied from a central reservoir.

19 *Use of Multiple Tools.* The increasing use of tools in multiple is a feature that is noticeable in connection with the modern machine shop. Milling machines are now quite extensively used having several spindles, making possible the finishing of three or even five sides of a casting at one setting, many holes are drilled simultaneously and in practically the same time formerly required for drilling one hole, and so on.

20 *Better Facilities for Setting up Work.* The up-to-date foreman or superintendent has come to realize that the efficiency of his shop depend largely on the amount of attention given to the little things. The furnishing of proper clamps and bolts to machine tool operators is a case in point. Poor bolts and warped clamps around a machine often double the time required for setting up work. At the present, most shops are equipped with proper clamping facilities and, in many cases, clamps of the right shape and bolts of the right length are furnished for each particular job, along with the other tools, such as cutters, reamers, etc.

21 These tools are being kept in the toolroom instead of being kept at the machines as formerly; thus the responsibility for their maintenance in first class condition is concentrated in the toolroom, where they are inspected upon being returned after their use in connection with each job, and any necessary repairs promptly made. The difficulty of holding a large number of men responsible for the upkeep of these tools is thus avoided, and each workman has a larger variety of bolts, clamps, blocks, etc. to draw upon than he can possibly have where each man has his own supply.

22 *Location of Tools and Lighting.* More attention is given to the relative location of tools in the shop, in order that all machining operations can be performed with no unnecessary handling of the work, the aim being to finish parts by advanc-

ing them from one tool to another in a direct line without any see-sawing or useless movements. Shops are constructed so that the light will be properly diffused, which makes it easier for the machinist to do accurate work and reduces the amount of spoiled work. The physical comfort of the workmen is also receiving more and more attention.

23 *Drilling Machines.* High-speed steel has been substituted for carbon steel in the manufacture of twist and flat twist drills with marked improvement in capacity. The speed of drilling has been increased two or three times, if not more. The drilling machine, the most common machine tool, has been redesigned to meet the new requirements and so rapid are some of the most highly developed machines on the market, that holes can be drilled in boiler plate quicker than they can be punched.

24 The claim is made by engineers who have carefully investigated the matter, that eighty per cent of all the holes drilled in general manufacturing are three-quarters inch in diameter or less. The fact is pointed out that general purpose drills with a capacity of from one-eighth inch to three inches are not efficient except within a narrow zone somewhere between the two extremes cited, desirable as they are when on deep drilling or on large diameters requiring a geared drive; hence the general recognition of the importance of comparatively small capacity drilling machines in the equipment of efficient plants.

25 Multiple drilling machines with from two to fifty or more drills in operation simultaneously, have been developed. Inverted drilling machines with which the capacity of drills is increased largely because of the rapid clearing of chips from the holes are being used with satisfaction, also multiple drilling machines working in several planes simultaneously, making feasible the drilling and reaming of all holes in machine parts such as automobile cylinders at one operation. Another development is the rotary table semi-automatic drilling machines which relieve the operator of lifting and lowering the spindle and engaging and disengaging the feed.

26 A minor improvement of machine shop equipment which has increased the productive capacity of single-spindle drilling machines is the so-called roller grip drill chuck which enables the operator to insert and remove drills, reamers, counterbores and other tools without stopping the spindle. These chucks are useful for certain kinds of work requiring drilling, ream-

ing and counterboring operations. In the same connection, mention should be made of tapping attachments, stud setting chucks, drill speeders, and similar attachments which improve the working range of drilling machines.

27 The need of the old style reversing countershaft has been eliminated from drilling machines by automatically reversing tapping attachments, automatically opening stud-setters; and many screw-threading operations are now performed on drill-presses with special forms of automatically opening dies, at a great saving over the former method of chucking the work on a turret lathe.

28 *Lathes.* The improvements in lathes have been chiefly in matters of strength, power, and details of construction. Spindles are made larger and are supported in longer bearings, improvements have been made in carriages, tailstocks, tool-rests, apron mechanism, stops, ways, spindle noses, gear boxes, change gear and feed mechanisms, etc.. Three-stop cone pulley and double back gear headstocks have been widely adopted for high-power rapid reduction lathes, this construction providing a wide range of speeds with simple and efficient mechanism. Quick change gear mechanisms which enable the selection of gear combinations for screw thread cutting to be made practically instantaneously have been generally provided by lathe builders. The demand for simple lathes, that is lathes without change gears, lead screws and other standard features of complete engine lathes, has not been insistent. Hence we still have the anomaly of thousands of lathes in manufacturing plants that are never used for thread cutting but which have the change gears, lead-screws and other parts required for screw cutting.

29 The reason ascribed by one prominent lathe builder is that the application of the simpler mechanism required for feeding only, makes comparatively little difference in the cost of a lathe. The elimination of the change gears reduces the number of available feeds. But the chief objection is the loss of inventory value when regarded as second-hand tools.

30 *Wheel Lathes.* A remarkable increase of efficiency has been made in locomotive driving wheel and car wheel lathes. Ten years ago, turning the tires of two pairs of drivers was a good day's work, and most railway shops did much less. High-speed steel has worked perhaps one of its greatest triumphs in this field. Tire turning lathes have been developed to equal

the capacity of the best steels and the productive capacity has been increased to eight or ten pairs of drivers a day. The increase of capacity of steel tire car wheel lathes is nearly as great, having been raised from five or six pairs to eighteen or twenty pairs a day.

31 *Planer Drives.* A weak feature of planers and a serious limitation to the power of large planers, is the common shifting belt reversing mechanism. On small planers even the shifting belts are objectionable because of slipping and the characteristic squeaking noises, but on large planers their fault is of more serious nature. Wide belts necessary to transmit the required power at practical speeds cannot be shifted from the tight to the loose pulleys and *vive versa* quickly. Clutches of various designs are used with varying degrees of success. The reversing electric motor direct connected to the planer drive has been developed to the point that makes its success assured. Probably this change of drive is the most marked improvement in planers made in recent years. Many details have been improved and the greater strength and rigidity of the modern planer coupled with excellent workmanship insures accurate work.

32 *Milling Machines.* A change in the machines for producing plane surfaces has been going on gradually but surely. Planers, shapers and slotting machines are being displaced by various types of milling machines in manufacturing plants. As plants change from a building to a manufacturing basis, the superiority of the milling machine as a manufacturing machine gives it the preference. The development of coarse-pitch teeth milling cutters and of face milling machines, are two of the marked improvements.

33 Single pulley drive with which the maximum power capacity of a given width belt can be transmitted to the machine irrespective of the work spindle speed, and geared speed boxes giving a wide range of positive speeds are other important changes in design. The vertical spindle milling machine has been developed to a high plane of efficiency, especially for small work. Rotary table machines with quick action clamping devices revolving continually while the operator places the work in position and removes the finished parts, are coming into extensive use.

34 Characteristics of modern milling machines also common to other modern machine tools are convenience and ease of opera-

tion, starting and stopping levers being placed where the operator can grasp them without leaving his normal position; speed and feed levers so placed as to permit the operator to control the rate of cutting while watching the work; power traverse of slides on heavy machines; etc.

35 *Boring Mills and Boring Machines.* The boring mill has taken a commanding place as a machine tool for both light and heavy work. When equipped with turret heads and a proper complement of tools its productive capacity has been made second to none. Convenience of operation, economy of floor space, compactness of design, adaptability to use of lubricants on cutting tools, are some of the advantages of this machine which have been emphasized in the new designs brought out in recent years. The builders have studied to find the best order of operations and equip with chucks and tools that produce an output far in advance of that possible ten years ago.

36 The horizontal boring machine of the bed and carriage type which has been developed practically within the past ten years, partakes of the characteristics of the lathe, milling machine and boring mill, and in the improved designs is superior to any one, for certain classes of work. One of many uses to which it is devoted is that of boring jigs and fixtures for interchangeable production. Not only is it useful for jig making but it is peculiarly well suited for manufacturing machine parts interchangeably without the use of jigs. This important fact enables machine tools and similar high-grade machines to be economically produced on the interchangeable plan during the very active period of developing the design.

37 *Magnetic Chucks.* Magnetism for holding steel and iron parts for grinding, planing and turning operations has been made useful, especially for thin parts that are easily sprung out of shape by ordinary clamping means. Magnetic grinding, planing and lathe chucks have come into common use in plants having up-to-date equipment.

38 *Grinding Machines.* The surface grinder, especially the vertical spindle type, has made great strides during the last few years. The improvements in cylindrical grinding methods are also worthy of mention, especially the use of the heavy-duty grinder for removing stock formerly removed by a second or finishing cut in a lathe. Grinding stock from the rough as in the finishing of drop forged crankshafts is also a good ex-

ample of modern practice. The stage has been reached in cylindrical grinding practice which places the cylindrical grinding machine on a coordinate basis with the lathe as a tool for finishing cylindrical work. A feature of cylindrical grinding machines which has greatly increased productive capacity in multiple diameter work is the stop bar or semi-automatic measuring attachment which enables shouldered shafts, etc., to be duplicated without measurement. Machines for internal grinding of non-revolving work with planetary spindles provides for the economical and accurate sizing of engine cylinders and other parts difficult to rotate. Vertical grinding machines and rotary work-tables utilizing magnetic chucks or other quick action clamping means for quickly securing and releasing the parts to be ground have come into extensive use for high-grade interchangeable manufacturing. The development of the disk grinder from a mere smoothing machine to a powerful machine tool of great capacity for finishing plane and curved castings from the rough is one of the most interesting phases of modern practice.

39 *Screw Thread Milling.* One of the notable improvements in the cutting of lead screws, feed screws and other machine screws, especially those required to be exact in pitch and lead is the substitution of special milling machines in place of the common engine or screw cutting lathe. Milling screws is by no means a new idea but the commerical development of special screw thread milling machines has taken place within a few years past. The machines not only increase accuracy but materially reduce the labor cost, one man being able to tend from three to six machines.

40 *Jigs and Fixtures.* The development of jigs and fixtures for interchangeable manufacturing has been remarkable. The expansion of automobile manufacture has been enormous and most of the leading concerns employ jigs and fixtures exclusively, thus insuring interchangeability, low production cost and systematic production. Many improvements have been made in the way of clamping devices, standardization of bushings, handles, levers, frames, etc., too numerous to mention specifically. Toolmaking has been developed on manufacturing lines, and in fact, several concerns specialize on the making of tools, jigs, fixtures, punches and dies, and produce them exclusively for manufacturing plants.

41 *Gear Making.* The demands of automobile users for

quiet running gears have imposed on gear makers conditions very difficult to meet. The limits of error in shape and spacing of teeth have been greatly reduced, and coupled with the necessity of making highly accurate gears, often has been that of producing them from tough alloy steels, heat treated after cutting the teeth. Hardened and casehardened gears are also demanded with minimum limits of error. The planing process has been generally substituted for milling in the manufacture of high grade bevel gears, thus producing theoretically correct tooth shapes instead of the approximation possible only by the formed milling cutter process.

42 Gear hobbing machines have been widely adopted for cutting spur and spiral gears, because of the greatly increased capacity and simplicity of operation. Machines and methods for cutting the teeth of integral herringbone gears cheaply, have been developed, thus making this form of gear available for machinery generally in which it has not been commonly used because of high cost of the two-part type. The demand of automobile users for noiseless gears have led to grinding the teeth of gears after hardening to correct form, and form grinding generally, including splined shafts for automobile change gear shafts and similar parts. Progress has been effected in the making of gears by the hot rolling process, producing them thus with a minimum waste of material and of exceptional physical characteristics. Progress has been made in the use of rotary cutters in gear manufacture. The substitution of high-speed steel for carbon steel has, of course, made higher cutting speeds possible, and improved designs of gear cutting machines have in turn made the cutters work more efficiently because of greater power and rigidity of support. Exhausts to draw away the chips and cool the cutters have made a notable improvement in efficiency, making greater speed and smoother cutting possible.

43 *Small Tools.* The design and manufacture of small tools have been improved principally in details. There has been a tendency to decrease the number of teeth of milling cutters, making possible heavier roughing cuts with proportionately less expenditure of power. While the extreme coarse spacing of the teeth advocated by some leading engineers has not been generally adopted, all manufacturers of milling cutters have, to some extent, modified the tooth spacing of their cutters. Several

special milling cutters with inserted teeth have also been proposed and, to some extent, adopted. The tendency has been towards the design of easily adjusted removable blade type reamers, and several satisfactory designs have been brought out. The flat twisted high-speed steel drill has been commercially developed, and several modifications of it have been placed on the market. The main progress in tap making, perhaps, has been towards a more satisfactory shape of the flute, and several tap makers have made experiments in this direction.

44 In general, there has been an attempt to design inserted cutter tools to a greater extent than formerly. This activity has been prompted largely by the high price of high-speed steel which has made it necessary to make the cutters only from this material, while the body and shanks of the tools are made of machine steel. Many experiments have been made to find the steels best adapted for a given service and the best heat treatment for the selected steels. Improvements have been made in the tangs of twist and flat drills adding strength sufficient to enable them to stand up to the requirements of high-speed drilling and drilling machines.

45 *Micrometers and Gages.* During the past ten years, the micrometer has become a measuring tool of general use. Almost every mechanic employed in up-to-date shops, who owns a kit of tools, regards a "mike" as necessary as calipers. Many shops also supply them from the tool-rooms on the workman's checks. As the result of the general use of the micrometer, one-thousandth inch has become the unit of measurement for fixing limits, and a limit of one-quarter thousandth is not uncommon in grinding operations. Not only is there a great advantage in the matter of accuracy in the use of micrometers over the old style of calipers set to a scale, but there is a considerable saving in time through their use, both in the matter of setting to size and in eliminating the element of uncertainty, permitting the workman to proceed with his work with greater confidence. So general has the use of this unit become, and so convenient is it for small dimensions, that a strong movement is under way to make it the standard for measuring wire, sheet metals, etc., in place of the irrational and arbitrary wire and sheet metal gages. One of the largest electrical concerns abandoned the wire and sheet metal gage systems in 1904 and adopted the decimal system in which one thousandth inch is the limit for use in all specifications of wire, sheet metal, fibre, etc.

46 Standard length gages have been improved. The so-called Swedish gages are furnished under guarantee of error being not more than one one-hundred thousandth inch, per inch length, the limit of error being proportional to the length. Thus a gage one-tenth inch long has an error limit of one-millionth inch, and so on. Hence a stack of these gages presents an overall length accurate to limit of one one-hundred-thousandth inch per inch of length.

47 *Screw Threads.* The so-called United States or Sellers standard screw threads have come into general use for machine construction during the past twenty or twenty-five years and have proved generally satisfactory for locomotives, cars, steam engines, and other typical heavy machinery but the automobile brought a new condition for which the standard threads were not well fitted. It was found that the jar and vibration to which motor cars are subjected, speedily loosened the comparatively coarse thread screws and nuts threaded to these pitches, and the need of finer pitches was soon recognized. We now have the finer screw pitches established by the Society of Automobile Engineers, and the merits of these pitches have won them recognition in other lines of machinery where for constructive reasons, pitches finer than the United States standard were desirable.

48 The A. S. M. E. standards for machine screws, which were adopted after a thorough investigation of the problem, should be mentioned also, in this connection. No work that this society has done is of greater importance than that of fixing on standards of screw threads to be recommended to the engineering profession.

49 *Portable Tools.* An important factor in shop work is the portable electric motor drilling and reaming machine which has been developed in several efficient forms during the last decade. These portable machines, supplemented with the pneumatic riveting, chipping and chalking hammers, have virtually revolutionized shipbuilding, bridge-building, and structural steel work, and in the erection shop have wrought great changes, making possible rapid and efficient machine work on the parts as erected and thus saving labor and time through the elimination of transport to and from stationary machines.

50 *Power Hack Saws.* The first power hack saw machine was put on the market about twenty-five years ago. During the past few years the range and capacity of these machines has been greatly extended. They are furnished with quick return

stroke, relief action for back stroke, means for using the full length of the blade, angle chucks and other improvements that have made this humble machine a real machine tool of high efficiency and low operating cost. Blades of great durability are furnished at low cost.

51 *Brass Working.* The changes in brass working are principally in the development of automatic and semi-automatic machines for machining standard parts made in large quantities. Some of the machines have effected great reductions in cost, in some cases reducing the labor cost to one-fifth, or less, of that before the change was made. Carbon steel tools still have the call in some plants in preference to high-speed steel tools; carbon steel holds a keener edge and is generally more satisfactory for working the brass used in the manufacture of globe valves, cocks, etc. It is claimed, however, that much of the difficulty experienced in using high-speed steel on work of this character is due to improper heat treatment of the high-speed steel, and this contention seems to be borne out in practice as certain shops doing brass work of this character are using high-speed steel exclusively.

52 Chucks operated by compressed air have made a great improvement in the operating efficiency of brass lathes. The work can be chucked and removed without stopping the work spindle, thus saving the time and strength of the operator. The development of the air chuck has taken place chiefly within the past few years, and it is one of the principal improvements made in hand operated turret lathes.

53 *Manufacture of Guns and Pistols.* The methods of making guns, pistols and similar high-grade products have been revolutionized. A representative of one of the largest machine tool building concerns estimates that the efficiency of workmen in these lines has been doubled by the introduction of improved machinery and methods. When the fact is considered that high grade gun parts are made interchangeable, the limits of error allowed being very small indeed and that gun making is one of the oldest industries, the importance of the improvements made can be better appreciated.

54 *Press Working.* Press working machines, punches, dies and other tools, have developed to an extent not generally realized by engineers in lines not affected. Here again the development of highly specialized methods of manufacturing automobiles has had a marked influence. Crank presses of one thousand tons capacity are in use. Pressed metal forms of large size are

a commonplace. But not only has the development been remarkable in point of size, but also in detail of manipulation. Parts requiring several operations, for example, are turned out by multiple plunger presses, one finished piece being formed at every stroke. An interesting feature of press work is that shapes are produced impossible of duplication by any other known process. In this respect, press work differs from most other machining processes; it is possible to duplicate, for example, lathe or planer work by hand tools, but not so many drawing and forming operations in daily use. A branch of presswork little known is the extrusion of shells, tubes, collapsible tubes, etc., of copper, brass and alloys. Extrusion of bars in many shapes used in manufacturing locks, small machines, etc., has become a large industry which has been largely developed in recent years. The possibilities of extrusion are practically unlimited, and this process in common with other metal working methods extensively used has an important effect on the practice of shops using the shapes in their products.

55 *Heat Treatment.* The advent of the high-speed steels and the alloy steels used in automobile gears, shafts and other high grade machinery subjected to shocks has necessitated the development of furnaces and equipment for the scientific heat treatment of steel. Accurate determinations of quenching and annealing temperatures are absolutely necessary, and the pyrometer has become an indispensable instrument in the furnace room. Gas and oil furnaces have been greatly improved in the matters of efficient use of fuel and control of temperatures.

56 *Die Casting.* The production of alloy castings in metal dies has grown to large proportions. Gears, bushings, bearings, type wheels, machine parts, covers, etc., are produced accurate to pattern and free from fins. This phase of manufacturing machine parts has a decided bearing on machine design. The extension of die casting to include not only the low melting alloys but also brass and cast iron, promises to make decided changes in some lines. Cast-iron gears true to pattern on which machine work is reduced to the boring of the hub for the shaft, may become common in agricultural and similar grades of machinery.

57 *Ball Burnishing.* Finishing processes are important in giving attractiveness to manufactured goods. Hand methods are slow and costly and the natural tendency is to use automatic mechanical methods for finishing as well as for making. One

process of considerable interest because of its simplicity and effectiveness is the steel ball burnishing method, consisting essentially of a tumbling barrel partly filled with the articles to be finished and a mass of hardened steel balls of various sizes.

58 *Thermit Welding.* An effective process has been introduced extensively during the period covered, for welding heavy sections of steel and iron. The thermit process is being successfully used for welding broken locomotive frames, cylinders, crankshafts, propeller shafts up to any thickness and diameter. The fractures are soundly united by a steel bond applied *in situ* at a fraction of the cost of removing the parts, welding them in the smith shop, finishing in the machine shop and replacing. Hundreds of locomotive frames have been welded by this process with almost uniform satisfaction and at a saving.

59 *Autogenous Flame Welding and Cutting.* The development of oxy-acetylene and oxy-hydrogen welding and cutting torches has given the industrial world truly remarkable tools for building up or cutting apart. The welding of sheet metals is accomplished with speed and evenness hardly possible by any other process, and the cutting of steel or wrought iron is done close to the line and with such rapidily as to equal or exceed the performance of any machine tool adapted for the same work. Recent improvements make possible the cutting of all manner of shapes from steel plates up to six inches thickness so close to the outline of the pattern that a light finishing cut suffices to transform the piece into a finished die.

60 *Cranes, Hoists and Trolleys.* The general provision of traveling cranes, jib cranes, hoists and trolleys in modern shops have made a great change in the manner of handling work and the attitude of mechanics to big jobs. When a casting weighing many tons had to be machined in the old-time shop it was a herculean job to transport it from one machine to another and fix it in position. So general has the power traveling crane become in the past few years that it is a commonplace sight to see machine parts weighing many tons being transported through shops and placed on machines with no fuss and requiring the help of only one or two men besides the crane operator.

61 *Accident Prevention.* The prevention of industrial accidents has received wide attention in industrial establishments. In machine shops accident prevention is a relatively simple matter, but there are a few points of danger which have become generally appreciated, and all of the better types of machines are

equipped with guards to cover gearings, setscrews, flywheels and all moving parts not necessarily exposed. There are also certain sources of danger which exist in practically all manufacturing plants and the general rules to prevent accidents from slipping ladders, piles of castings, elevators, etc., are being applied.

62 Time and space will not permit going much more into detail, and the following are enumerated without elaboration: Introduction of ball bearings in the construction of machine tools, effecting a saving of power, increasing the efficiency of operation, and capacity through reduction of bearing widths; development of cam grinding machinery and attachments making possible the rapid and economical production of camshafts having cams integral with the shaft; development of the dynamic balancing machine and the general recognition of the need of dynamic balancing for high-speed revolving parts; artificial production of highly-efficient abrasives or cutting particles for grinding wheels, and improvements in grinding wheel manufacture; development of improved lubricating systems for machine tool bearings; development of machine tools to their utmost capacity by providing means for working the tools all the time, employing extra men to prepare work and also by tooling the machines to bring them up to their highest productive capacity; development of spline milling machines for cutting keyways, key slots, drift holes, cam grooves, recesses, etc.; finishing square, hexagon and other shaped holes by the broaching process, insuring interchangeability and rapid production at low cost; general improvement in sanitary conditions of shops, improved lighting facilities both by day and by night through the use of sawtooth roofs, large windows fitted with metal window frames, improved electric lights and means of distribution; provision of lockers; and the establishment of shop restaurants in localities that formerly had nothing better than the corner saloon.

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E. J. Kearney
Wm. Lodge

Members of Sub-Committee on Machine Shop Practice

GAS POWER SECTION

At the meeting of the Gas Power Section, held on December 4 during the Annual Meeting of the Society, the following officers were elected: Chairman, Prof. F. R. Hutton; Members of the Executive Committee, W. D. Ennis, W. H. Blauvelt, H. J. Freyn and C. H. Benjamin.

The address of the retiring Chairman, with discussion, here follows in somewhat abridged form.

RECENT DEVELOPMENT OF GAS POWER IN EUROPE

By H. J. Freyn, Milwaukee, Wis.

Chairman of the Gas Power Section

The development of the internal-combustion engine in Europe during the last year has been very marked and great strides were made, especially by the Diesel engine. The unparalleled progress of this prime mover, due primarily to the expiration of the basic Diesel patents, created a wave of enthusiasm, the crest of which swept Europe only a short time ago. To the careful observer, however, signs of an ebbing of this wave are apparent and more sober, more healthy views are gaining ground.

OIL ENGINES

Large Diesel Engines.—Without desiring to detract from the importance of the Diesel engine, investigation has proved to me that my warning against over-enthusiasm sounded about a year ago on a similar occasion was fully warranted.

In particular, I was disappointed to find that the achievements with large Diesel engines, above 1000 h.p., do not altogether coincide with the optimistic reports which have appeared in the technical press of the world during the past year or two. It is not certain that the large Diesel engine will be an undisputed commercial success

The American Society of Mechanical Engineers, 29 West 39th Street, New York

abroad, since the price of natural fuel oils is steadily increasing, thus largely limiting such engines to the use of tar oil.

The horizontal double-acting four-cycle M.A.N. Diesel engine in twin tandem arrangement of 1600-2000 b.h.p., which I had the privilege of examining at Halle a. S., is a splendid piece of machinery and operates apparently very satisfactorily on tar oil with a small addition of ignition oil. It is claimed that such an engine can be sold in Germany for from $30 to $32.50 per horse power, against $35 per horse power for a steam plant. It would be expected, however, that the repair and maintenance cost would be much higher than for a steam plant and even higher than for present gas engines, on account of the high pressures and temperatures which are essential with the Diesel working principle and because of carbonization at partial loads which can be prevented only by scrupulous cleanliness. In countries where the price of coal is high, this engine type may have some importance, and a number of such engines of even larger unit capacity than mentioned have been sold in France and Russia, where fuel conditions are favorable for this type.

Small and Medium Size Diesel Engines.—The Diesel engine in sizes of from 40 or 50 h.p. in single-cylinder units, up to about 600 h.p. in four-cylinder units, plays a vastly more important part abroad. It has unquestionably come to stay and has reached a high degree of perfection which places it in line with the corresponding steam or gas-engine plant as far as reliability and cost of operation are concerned, and far ahead of its competitors from the standpoint of fuel economy. It is amazing to note how many manufacturers of gas and steam engines abroad have taken up the manufacture of Diesel engines, because they found that the sale of suction gas producer plants and smaller steam engines had fallen off alarmingly during the last few years.

The reason is plain. The single-acting, four-cycle, single or multicylinder Diesel engine, but particularly the former, is comparatively simple in construction and operation, especially when its unequaled efficiency is considered, for it is certain that, generally speaking, complication of any mechanical contrivance increases with increasing efficiency. This engine is always ready to be put in service at a moment's notice and has no standby losses; it does not require upkeep and attendance of boilers or gas producers and its cost compared with that of a steam or gas plant is reasonable. It can be installed in the basements of buildings below occupied dwellings, whereas in Europe boilers are not permitted in such places. One of the greatest advantages which can not easily be expressed in figures, but is of vast importance to the consumer, is the fact that the actual fuel consumption of Diesel engines, taken over long periods of operation, does not materially exceed the guaranteed figures, whereas in gas producer and steam plants this excess is quite considerable. A few months ago a German technical periodical contained an article showing that the actual fuel consumption during a period of one whole year was for certain Diesel engine plants only 14 per cent higher than the guaranteed figures given by the manufacturer, whereas it averaged 120 per cent more in high-class steam locomobile plants. In this comparison 27 installations containing units of 50 to 80 h.p. were investigated, 12 of which were locomobile plants, whereas 15 contained Diesel engines. In a Diesel plant the human element, the skill of the operator, must have much less influence upon the fuel economy than in a steam or producer gas plant where everything depends upon the efficiency and intelligence of the fireman and producer attendant.

While the Diesel engine was originally a vertical engine, the last two or three years have witnessed a remarkable development of the horizontal Diesel engine. With few exceptions the manufacturers of vertical Diesel engines have branched out to build horizontal engines as well for purely commercial reasons. Experience shows that the fuel consumption is only very little, if any, higher than that of vertical engines, but the horizontal type is decidedly preferred by the customer, not only on account of its lower cost, but particularly owing to its greater simplicity and better accessibility. Especially the horizontal Diesel engine with Lietzenmayer's open fuel injection nozzle offers these advantages in their full measure. The open nozzle is simpler, can be more easily cared for by unskilled attendants, gives better results when burning heavy oils and is less sensitive in its action than the so-called closed injection nozzle of the original Diesel engine. The horizontal open nozzle oil engine has the additional advantage that certain essential accessories, such as the starting gear and the fuel pump, can be designed much simpler than for the other type. Many engines of the former type are in very successful service, using all kinds of fuels and installed for various purposes, for instance, for power transmission, for operating flour mills, for lighting factories, sanitariums, office buildings, department stores and for electricity works.

The only difficulty of which some users of small and medium Diesel engines sometimes still complain is caused by the discharge valves of the air compressors for fuel injection, and although these difficulties have been greatly reduced, numerous efforts are being made to materialize the dream of the "compressorless" Diesel engine. I had the privilege of seeing a 12 h.p. experimental engine of this type in operation, which seemed to give good results, since an oil consumption of only 0.48 to 0.5 lb. per b.h.p. hour is claimed, but it is not certain that this principle, which has been tried many times before, would be applicable for larger engines.

Marine Engines of the Diesel Type.—In view of the great importance of the Diesel engine for ship propulsion, there is little wonder that great effort is directed by many manufacturers to the design and construction of an engine which, while having nearly the same excellent fuel economy as the stationary engine, will also meet the severe requirements of simplicity, reliability and reduced first cost. That the last condition is not yet fulfilled is shown by the fact that, according to authentic information, the cost of an 800 h.p., four-cylinder, two-cycle marine engine recently built was 50 per cent higher than anticipated and 150 per cent higher than for a corresponding steam engine equipment. I was nowhere able to find the 10,000 and 15,000 h.p. Diesel engine ships of which I had read, and even enthusiasts do not believe that our modern leviathans will be propelled by Diesel engines.

The largest single Diesel engine unit now propelling any ship develops not over 2000 h.p. and there still remain many obstacles to be overcome before the single-acting multicylinder, four or two cycle Diesel engine on board ship is supplanted by the double acting engine. Vertical engines of the latter type are still in the experimental stage and their future does not appear very promising on account of the serious mechanical complications of scavenging pumps and multiplicity of scavenging valves in each cylinder head.

The lack of simplicity in these designs has prompted experiments with the so-called "valveless" two-cycle type, which presumably will become the large marine Diesel engine of the future. One valveless two-cycle experimental engine of 260 h.p. is claimed to have shown an economy as good as that of a regular two-cycle engine with scavenging valves. The mean effective pressure obtained reached 125 lb. per sq. in., which is truly remarkable in view of the extremely simple scavenging method employed.

The Junkers Oil Engine.—Among the valveless, two-cycle engines, the Junkers oil engine has attracted a great deal of attention. It has reciprocal pistons, a three-throw crankshaft, and differs essentially from the regular type. An advantage is the excellence of the form of combustion space which, from a thermodynamic point of view, at least, gives it the distinction of being the best oil engine. Practical experience alone will tell whether its unusual design and certain mechanical disadvantages will be offset by this advantageous feature. One of the foremost authorities in Europe very graphically characterized the Junkers engine as an oil engine built around a given perfect combustion chamber in contra-distinction to all other Diesel engines where it is attempted to provide a satisfactory combustion space in an existing engine. Only a few smaller engines, mostly for marine propulsion and of the twin or three-cylinder vertical type have been built abroad. The tandem arrangement of cylinders which results in the same number of crank efforts realized in ordinary single-cylinder, double-acting, two-cycle engines has so far been applied only on two 800 h.p. three-cylinder vertical engines to be fitted in a vessel of one of the largest steamship companies. Aside from two experimental engines in Prof. Junkers' famous laboratory, no horizontal engines of this type have been built and opinions abroad are much divided concerning the future of the stationary, horizontal, tandem Junkers engine.

Conditions Affecting the Development of the Diesel Engine.—If conditions in Europe are not altogether favorable for the development of the large Diesel engine, they are much less so in this country. The misapprehension frequently prevails that the Diesel engine must have a wonderful field of usefulness in countries where crude oil is produced in very large quantities, but such is not the case. The price of oil fuel in any locality must be considered in connection with the prevailing coal price to determine whether a Diesel engine installation is economically efficient or wasteful. Cheap oil fuel will favor the Diesel engine only where coal is very expensive, as on the Pacific Coast, whereas high oil and low coal prices will exclude it from any part of the country where such conditions exist. Considering that the total cost of producing power is made up of a number of items, as interest on the money invested and depreciation of the plant, cost of fuel, cost of attendance, maintenance and repairs, cost of supplies, etc., it is evident that in Europe where fuel prices are from two to three times higher than in this country,while labor is only one half to one third as much, the item of fuel cost constitutes a very high percentage of the total cost of power, particularly since the other items, such as interest and depreciation, attendance and repairs are actually much lower and thus form a still smaller percentage of the total cost.

With us conditions are practically reversed: Our fuel cost is not only lower and our labor cost much higher than in Europe, but, moreover, the quality of our mechanical labor is not as excellent, and thus the fuel cost plays a much less important role in the total cost of power than the items into which labor largely enters: further, the lower standard of manufacture, and especially of maintenance, favors the use of simple although less economical machinery.

To what importance the use of coal tar oil has grown on the continent can be judged from the fact that France has to rely on this Diesel engine fuel almost exclusively on account of the very high import duty on natural oils. In Germany a number of collieries have combined to form a company for the utilization of tar which operates a large factory at Meiderich, where, at present, over 300,000 tons of tar a year is distilled, producing over 80,000 tons of tar oil. This is contracted for in larger quantities at a price of approximately $12.50 per ton (5 cents per gallon). With the tremendous increase in demand, it is expected that before long this one factory alone will have a capacity for handling one million tons of tar per year, producing 300,000 tons of tar oil.

It is estimated that the total world production of coal tar oil is even now in the neighborhood of 1,000,000 tons per annum, and since the recognition that coal is too valuable a fuel to be wasted in our present day furnaces is spreading more and more, the number of by-product coke oven and by-product gas producer plants will steadily increase, especially in our country, so that the total production of tar oil is certain soon to double and treble, adding to our supply of natural liquid fuels an artificial product which will by legitimate competition check the advance in the price of the former.

The heat value of tar oil is over 17,000 B.t.u. per lb. and its consumption in the Diesel engine is, therefore, not very much higher than that of natural oil, varying now from 0.49 to 0.46 lb. per b.h.p. hour, according to the size of the engine.

The operation of medium size Diesel engines on tar oil, especially of those above 50 h.p. per cylinder and with open fuel injection nozzle is satisfactory. For smaller engines the addition of a so-called ignition oil is necessary, which somewhat complicates these engines.

GAS TURBINES

Renewed activity is noticeable abroad in the matter of designing an adequate gas turbine. The foremost authorities are convinced that the gas turbine will soon come to stay and, in view of the universal tendency towards high-speed rotative machinery, the statement would seem warranted that when the gas and oil turbine does come it will revolutionize power production in the large steel centers and wherever natural fuel oils abound in this country. A large experimental gas turbine in Germany is operating splendidly, mechanically speaking, although the problem of satisfactory thermal efficiency still remains to be solved.

INDUSTRIAL WASTE GASES

The use of the so-called "industrial waste gases" has progressed considerably. The four most prominent manufacturers in Germany alone are now building large gas engines for blast furnace and steel works at the rate of 120 per year and a number of twin tandem engines of 5000 b.h.p. operating very satisfactorily on rich coke oven gas can now be seen in German coking plants.

The splendid results obtained with gas blowing engines in Germany have prevented the turbo-blower from getting a firm foothold in that country, although its use in France, England and Russia is steadily increasing. Blast furnace gas engines for blowing and electric power purposes and even for operating rolling mills are to-day the standard equipment for old and new plants, even where the coal price is fully as low as in our Pittsburgh district. Within the last two years the use of coke oven gas for producing electric power by gas engines has greatly increased, and after overcoming the many earlier difficulties the coke oven gas engine is today just as safe and reliable as the blast furnace gas engine. These difficulties arose principally from overrating the engines, and from sulphur in the engine gas. Since the reasons for the trouble were recognized, the causes, or their consequences, are now avoided, so that in a number of plants sulphur of considerably over one grain per cubic foot of gas is very successfully handled in coke oven gas engines if the proper very simple precautions are taken.

DETAILS OF CONSTRUCTION

In regard to the detail construction of the modern German gas engine a few remarks may be of interest. The most prominent gas engine builders are now governing their engines on a simple combination quantity-quality regulation principle. The valve gear has been much simplified by all manufacturers, and gas engine prices are, generally speaking, lower than they ever were before. The gas cylinders, after a few unsatisfactory attempts to use cast steel, are invariably made of cast iron and with the exception of a few types are cast in one piece with integral water jacket. They are often provided with hard cast iron liners. The cracking of gas cylinders is now much reduced by proper design, selected material and better pouring methods. Experience has taught that the life of a gas cylinder can be materially increased if the water jackets are thoroughly cleaned from all scale and muddy deposit at regular intervals of from four to eight weeks, depending upon the character of the cooling water used. It was found by experiment that the average temperature of the cylinder wall increases at an amazing rate with even a very thin layer of scale forming in the water jacket, and in certain plants with hard cooling water, acid and wire brushes are resorted to from time to time to take the accumulated scale off the cylinder walls.

Gas cylinders on electric engines crack more frequently than on blowing engines because the former carry much higher loads than the latter and because electric engines are usually shut down oftener. It was found that frequent shutting down and starting of gas engines shortened the life of the cylinders materially if the engines were allowed to cool off too much during shut downs.

The average life of a gas cylinder in the large steel plants in Germany is pretty generally reckoned to be from five to six years. This is accepted as a matter of course and the expense incurred by replacement is simply distributed over this number of years in the cost figures.

The cost of producing electric power in German blast furnace and steel plants is about $2.70 per thousand kilowatt hours, comprising $1.25 value of the raw blast furnace gas and including cost of gas cleaning, cost of labor, repairs, and supplies of all kinds, but without interest and depreciation on the money invested. This figure applies on an annual output of about 100,000,000 kw. hours and a use factor of approximately 60 per cent.

The gas pistons are generally ribless iron castings, although for large engines cast steel is used. One concern has recently introduced for blast furnace gas engines solid, non-cooled, forged steel pistons of one piece.

The piston rods are now usually made of open hearth steel of about 100,000 lb. tensile strength, uncambered, and their diameter is approximately 26 per cent of the diameter of the gas cylinders. A variety of piston rod coupling designs is used but the threaded connection enjoys the best reputation. It is noteworthy that crossheads are made of forged nickel steel.

No uniformity of design can be claimed for piston rod packings, but they invariably consist of single or double sectional cast iron packing rings pressed against the rod by garter springs and separated by solid one-piece rings forming from 12 to 14 chambers. It is universally claimed that the clearances of the ring sections must be reduced to the possible minimum. So-called fire rings are sometimes used, but several builders object to such solid rings.

The exhaust valves are made of forged steel or of Durana metal and are now almost exclusively of the non-cooled mushroom type. Some builders, however, still prefer water-cooled exhaust valves for coke oven gas engines.

GAS CLEANING METHODS

The progress of the large gas engine in Europe has been accompanied by great improvements in the method of purifying blast furnace gas. Until recently two systems of cleaning gas for engine purposes were largely in use, both of the so-called " dynamic " type, and by using considerable quantities of water: the hydraulic fan and the Theisen washer. Results obtained with these appliances regarding both cleansing efficiency and cost of operation are satisfactory. Nevertheless, they now are superseded in Europe by new processes, which still further reduce not only the cost of installation, but principally the cost of purification on account of the smaller power and water consumption.

One of these new methods is a radical departure from the former wet-cleaning processes and works on the principle of filtering the gas in a perfectly dry condition, so that no water is required save that necessary to cool the engine gas to atmospheric temperature. The filtering is achieved by means of Beth filter bags, which are made of special fabric and suspended vertically in several air tight compartments. The raw blast furnace gas coming from the furnaces at high temperature is first cooled by radiation to about dew point (around 130 deg. fahr.) and thereupon superheated approximately 20 to 30 deg. fahr. by using any available source of heat, such as waste heat from gas engines, exhaust steam or even the sensible heat of the raw blast furnace gas itself. By cooling the gas a large amount of moisture is removed and the scorching or burning of the filter bags prevented, whereas the subsequent superheating avoids condensation of the remaining vapor and clogging of the bags. The raw gas under the action of a fan passes from the inside to the outside of the filter bags, depositing all impurities on the surface.

The layer of dust naturally increases continually and would eventually render the bags impenetrable, were it not for an automatic mechanism which in a fashion, similar to that used in flour mills, shakes the bags at regular intervals of about four minutes and causes the dust to drop off. Simultaneously the compartment which is to be cleaned is automatically separated from the others, and the direction of gas current reversed; the purified gas surrounding the filter bags now enters the latter, opening the pores of the filter material, which were previously closed up by the passing dirty gas current. The dust shaken off the filter bags falls into a receptacle, from which it is removed in a perfectly dry condition.

Two experimental filter plants installed at Halberger Huette and Duedelingen have capacities of about 10,000 and 14,000 cu. ft. of gas per minute and clean the gas for gas engines only. It is claimed that the power consumption is 2.5 to 3 times lower than that of hydraulic fans and Theisen washers, that the water consumption is only one-fifth to one-sixth of the corresponding requirements of wet-cleaning plants, and that the dust content in the purified gas is below 0.0004 grains per cu. ft., or fifteen to thirty times lower than in the purified gas obtained with the older wet cleaning apparatus. The cost of operation is furthermore claimed to be lower and the cost of installation only a little, if any, higher.

As the advantage of using thoroughly cleaned blast furnace gas, not only for gas engines, but for boilers and stoves is more and more appreciated, this "Halberger" System causes much interest and comment and several prominent blast furnace men abroad assert that the cleanest blast furnace gas obtainable at comparatively low cost is just clean enough even for boilers and stoves, which, after all, form precisely as important and costly a part of their installation as the gas engines. In certain districts of Germany and Luxemburg, water is exceedingly scarce, and the laws against river contamination are so strict that large sums of money have to be spent to purify the washing water before it can be disposed of. Setting tanks of huge area have to be installed, and the disposal of the mud presents difficulties and is very costly; furthermore, flue dust in a moistened condition is of no use except as filling in material and since it contains considerable quantities of iron ore, its disposal in such a way is rather wasteful.

On the strength of the satisfactory results obtained, many blast furnace plants in the Minette District, and even in Westphalia, have decided to install gas filtering plants, varying in capacity from 17,500 to 140,000 cu. ft. of gas per minute. One manufacturing concern alone, which acquired the rights for Germany, had in the month of July orders for twenty-one plants, with a total capacity of 825,000 cu. ft. of gas per minute and valued at one million dollars.

The other new system of gas cleaning makes use of the " disintegrator " principle. Two well known concerns in Germany, specializing in gas washing apparatus, have developed this system on somewhat different lines, and one of them claims to have on hand orders for disintegrator gas washers capable of purifying 1,750,000 cu. ft. of gas per minute. One machine only is used for preliminary purification of boiler and stove gas, from 2 to 3 grains of dust per cubic foot to 0.088 to 0.175 grains, with a water consumption of only 10 gallons and a power consumption not exceeding 0.072 h.p. per 1000 cu. ft. For gas engine purposes two disintegrators are placed in tandem which causes the power consumption to increase to 0.13 h.p., the water consumption to 18 gallons per 1000 cu. ft., whereas the amount of dust in the gas drops to 0.0044 — 0.0088 grains per cu. ft.

No change has taken place in the method of purifying coke-oven gas; bog or swamp ores are still used for sulphur cleaning, although one plant at least has succeeded in overcoming the disadvantage of occasional regeneration of this material by alternate exposure to the air by regenerating it continually.

GAS PRODUCER DEVELOPMENT

It seems extraordinary that in spite of the high price of coal the development of the gas producer for power purposes has not kept pace in European countries with that of the gas engine. For many years the Mond gas producer with sulphate of ammonia recovery has been well introduced in England, and recently much interest has been shown in Germany in such plants, which offer material financial advantages over ordinary gas producer installations. Since a great deal of sulphate of ammonia now finding a ready market as an artificial fertilizer, can be recovered from the coal, the cost of gas making is considerably reduced, and installations are known where the saving thus obtained reaches the figure of $2.00 per ton of coal, which in many cases is as much as, or more than the value of the coal itself. The gas manufactured in such plants has a heat value of about 150 B.t.u. per cu. ft., and is of very uniform quality; on account of the removal of tar and dust, it is particularly adapted for gas engines, but its low cost makes its use very profitable for all kinds of metallurgical purposes, such as heating and annealing, for calcining, roasting, distilling, for glass works operation and a variety of other industries. Ordinary coals as well as low grade fuels, such as peat, lignite, brown coal, etc., can be very successfully gasified in such plants.

COKE OVEN GAS

The growing demand for coke, which goes hand in hand with the soaring pig iron production of the world, has caused a remarkable increase in coke oven plant activity. The days of the wasteful "Bee-Hive" coke oven are fortunately past, and the highly economical by-product coke oven is gradually taking its place. The manufacture of coke entails the accumulation of large quantities of coke braise, which cannot always easily be disposed of. Successful attempts were recently made in Europe to gasify this coke dust in special gas producers. One system operates with liquid slag very much on the order of a blast furnace, whereas the other adapts a well known European producer design to the special requirements of gasification of very fine fuels. In a number of European blast furnace and coke oven plants, this coke braise will be gasified in such producers, and the resulting gas of about 150 B.t.u. per cu. ft. admixed to blast furnace gas, to increase its quantity and improve its quality.

Mixtures of industrial gases are used more and more for metallurgical and power purposes abroad; in one plant in England a mixture of blast furnace and coke oven gas is used for all heating purposes and to operate gas engines. At first glance it may seem difficult to obtain a sufficiently uniform mixture of two gases so different in specific gravity, but experience has shown that modern blast furnace gas washers of the revolving type, such as fans, Theisen washers and disintegrators are splendidly adapted for this purpose, and that changes in the quality and heat value of the mixed gas of even considerable magnitude, do not seriously affect the operation of gas engines.

In this particular steel plant another very interesting novelty of perhaps great importance for future gas engine application is in operation, namely, a system of overloading four-cycle gas engines 25 to 35 per cent of their normal capacity.

NEW GAS ENGINE METHOD

The method devised and patented by one of the foremost gas engine manufacturers in Germany and which creates an almost perfect analogy with the condensing plant of steam engines consists in scavenging ordinary four-cycle gas engines and introducing the fresh mixture under a pressure somewhat higher than atmospheric. This is achieved by raising the pressure of the combustion air and gas in turbo blowers to a gauge pressure of a few inches of mercury and by scavenging the spent gases of the previous power stroke with a blast of this air, subsequently introducing gas and air under slight pressure into the combustion chamber. By utilizing the waste heat of the gas engines for raising steam in suitable waste heat boilers and driving steam turbines direct-connected to the turbo blowers, the power requirements of the auxiliaries can be amply supplied without resorting to outside sources of power, nor detracting from the increased output of the gas engine generator.

An overload of 35 per cent was attained without raising the initial pressure—an important point—and without appreciable increase of the heat absorbed by the cooling water; the thermal efficiency of the scavenged engine was found to be somewhat better and the mechanical efficiency considerably better than that of the non-scavenged engine.

In another steel plant two tandem engines of 1360 kw. or 2000 b.h.p. normal rating (at 65 lb. m.e.p.), which were provided with generators of 1700 kw. capacity in anticipation of the overload scheme, can carry loads of 1800 to 2000 kw.; before the changes were made in April, 1912, the average kilowatt output per engine in twelve hours as ascertained from the log book was 13,000 kw. hours, but since installing the scavenging plant, the average output was raised to 18,000 and 20,000 kw. hours in a twelve-hour run, corresponding to an average increase of approximately 40 per cent.

Regarding the financial aspect of the matter, it can be shown that the capacity of an existing gas engine plant can be increased 30 per cent, provided the generators are large enough, at a considerable saving compared with the cost of providing for this increase in capacity by installing additional non-scavenged units.

HUMPHREY GAS PUMP

The technical press has been rather silent during the last year regarding the Humphrey pump, but according to reliable information, this is by no means an indication that this gas pump has passed out of existence; on the contrary, one of the largest concerns in Germany is devoting much time and effort on experiments to generate electric power with such a pump at its factory, and a 40,000,000 gallon pump will be installed in England on which a coal consumption of one pound per effective pump horsepower was guaranteed.

DISCUSSION

William T. Magruder. I had the pleasure of spending a few months on the other side of the water this past summer, and looked at the subject of gas-power from a different point of view from Mr. Freyn. I considered it both from the engineering and educational sides and received much information not only from manufacturers as to costs and details, but also from professors of engineering. In the first place, I noted, in both Germany and England, that the most important developments in gas and oil engines in recent years have been made by consulting engineers, who are graduates of universities and engineering colleges, many of whom are professors or lecturers who are doing much advanced work along the line of investigation. Secondly, that societies like the Institution of Civil Engineers and the Institution of Mechanical Engineers, the British Association for the Advancement of Science, and the Society of German Engineers, are deeply interested in the subject of gas power, and their members are doing the largest part of the scientific work. It is interesting to note the number of papers presented to these learned societies from men who have received higher degrees, such as Master of Arts, Doctor of Science, and Doctor of Engineering. I would respectfully recommend their activities to the attention of The American Society of Mechanical Engineers, and the American Association for the Advancement of Science, as it is high time that they too become more active and that our Research Committee on Gas Power did something in the way of scientific research in the field of gas and oil engines.

Few Americans appreciate the tremendous difference between the gas and oil engine industry in Europe and in America. The price of gasolene in Great Britain is 40 to 45 cents for an Imperial gallon, which is the equivalent of 33 to 37 cents for the American gallon, or double the price as compared with 15 or 16 cents, paid for the same amount in the United States. It can readily be seen why Englishmen are now looking for a cheaper fuel than gasolene, as Americans will be shortly doing, and why oil engines operated by tar oil are being used especially in Germany, although it is a much less desirable fuel than other oils on account of the difficulty in igniting it. It can be seen why gas producers operated by the combustion of peat briquets in Scotland and Germany and bituminous gas producers are favorably regarded. Because Dr. Mond happened to live in England, the Mond producer is more commonly used in England than in Germany. It used to be that 1500 h.p. was the smallest unit that could be economically installed and used. I was told by one manufacturer in England that now they could be economically used in England in plants as small as 800 h.p. One of the interesting and surprising things was to see the large numbers of gas and oil engines on the testing floor and of producers in the assembly buildings, to go through the painting and shipping rooms and to be told that the output of several of the works visited was from 2000 to 3000 gas and oil engines per year and 30 producers a month. The reason for this, it was stated, was the low price of city gas and the relatively high price of coal.

The smaller proportionate number of motor cars used in England as compared with this country is doubtless due to the relative prices of suitable fuel. I was informed that there are 150,000 motor cars in Great Britain for a population of fifty million people, or about three cars per 1000 of inhabitants. In this country, almost 1,000,000 motor cars were registered in 1912, to say nothing of the motorcycles, motor boats and other users of oil-power; or one car for each 100 of the inhabitants of the United States, and that the ratio of cars to people in this country is three and one-third times as large as in Great Britain. If there were the same proportionate number of cars used in Great Britain and on the Continent, for which I have no accurate figures, as in America, the price of fuel in Europe would be still greater than it is. But to this large number of motor-car engines must be added more than 1,000,000 gasolene engines used for farm work and in motor boats in this country. Taking the average horsepower of the motor cars to be 25 and of the motor boats and farm engines to be 10, thirty-five million horsepower of gasolene engines are immediately available for the practical generation of power in this country. Suppose they used as a minimum at rated load ¾ lb. or 1 pt. of gasolene per h.p. per hr. for 1 hour of use they would generate thirty-five million horsepower and require four and a half million gallons of gasolene at an estimated cost of $700,000. The total annual supply of American gasolene is estimated to be one billion, five hundred million gallons, and that would last only 333 hours. If every gasolene engine were run at its rated load each day, the annual distillation of gasolene in this country would be sufficient to permit them to be operated for only one hour per day, or 333 hours per year. In other words, our present annual output of gasolene is sufficient to operate continually at their rated load only 5 per cent of the gasolene engines now sold and in operation.

These being the facts as I gather them from statistics published by the Bureau of Mines, and other reliable sources, it can readily be seen to be a case of supply and demand. It is probable that some other fuel than gasolene must come into use for oil engines and that this fuel will be kerosene. When the vast amount of kerosene that is now on the market is realized, three billions of gallons being distilled annually, it seems certain that kerosene oil will come into very great and general use in the next few years.

It was interesting to note how the kerosene oil engine is being introduced and used in England and on the Continent in place of the gasolene engine and particularly in the form of the so-called semi-Diesel oil engine, and from which results below ½ lb. of kerosene per h.p. per hr. have been reported by expert engineers. This is a branch of the gas power field that Americans are only beginning to cultivate with any degree of efficiency.

The figures that I obtained abroad in respect to the fuel consumption of Diesel engines may be of interest. The actual fuel consumption of a large plant on test was 0.44 lb. of oil per b.h.p-hr. at full load, 0.45 lb. at three-quarter load, 0.47 lb. at one-half load, and 0.62 lb. at one-quarter load. Other figures obtained in tenders for alternating-current electrical units of 200 to 300 kw. capacity running on crude fuel oil having a calorific value of 18,000 b.t.u. per lb., varied for four-cycle Diesel engines from 0.603 to 0.662 lb. at full load per kw-hr., from 0.64 to 0.70 lb. at three-fourths load, from 0.70 to 0.83 lb. at one-half load, and from 1.14 to 1.27 lb. of oil per kw-hr. at quarter load. These figures confirm Mr. Haynie's remarks upon this point.

With respect to the first cost of Diesel engines, Mr. Freyn has given \$32 to \$35 per h.p. The lowest price given me in England on Diesel engines was \$35 per b.h.p. and from \$35 to \$45 seemed to be the usual price for Diesel engines in the larger units.

In the tenders above referred to for Diesel units of 200 and 300 kw. capacities, the prices for the engines directly coupled to alternating-current generators varied from £13-16-4 for the 300-kw. units at 192.5 r.p.m., to £22-17-3 for the 200-kw. units at 165 r.p.m., and the average price of 23 four-cycle Diesel engines and alternating-current generators of 200 and 300 kw. capacities from seven builders averaged £17-7-11 per kw. of rated capacity. These are the equivalents of \$67, \$111, and \$85 respectively. The horizontal engine units were about \$15 per kw. less in price than the vertical ones. The corresponding figures for the gas-producer plant with engines and generator without foundations were £19, or \$92, installed.

With respect to the Diesel ships, any one who has seen them operated, especially in local service, and seen the delightful ease and speed with which the engineer operates their valves, stops the generation of power and the rotation of the screw, and then reverses and starts up in the opposite direction, and seen them come to rest as soon as their momentum can be absorbed, cannot but admire the Diesel engine for marine purposes.

With respect to the Diesel locomotive, I cannot say as much. The one I saw would be simply prohibitive at the present time on account of first cost, labor in operation, and a number of other difficulties, which may yet be overcome.

The whole subject of oil power at the present time reduces itself to costs of fuels and to the usual commercial and engineering problems. If our commercial friends would be more fearless and less secretive and our scientific friends would be more energetic, the cause of the Diesel and other forms of oil engines, and of gas power in general, would be advanced.

W. R. HAYNIE (written)[1]. It may be generally stated that all heavier oils, if free from non-combustible foreign matter, can be readily used in Diesel engines. The non-combustible foreign matter is sand or mineral matter that will not burn, but will cut the engine cylinders; it can always be removed either by precipitation or by forced straining, and there is no petroleum residue of however heavy specific gravity, the ignition of which is not attainable by the temperature created by 30 to 35 atmospheres of compression. The complete combustion of the fuel oil in the cylinders after ignition is, however, entirely dependent upon the process of handling the fuel before it enters the cylinders. The period during which the oil has to be consumed is very short, only a small fraction of a second, and therefore the process of combustion must take place almost instantaneously. The rapidity with which the oil is consumed depends not upon its specific gravity or chemical properties, but upon the size of the particles or globules into which it is broken before coming in contact with the ignition temperature. The combustion proceeds over the surface of the particles, and the smaller the particles, the more quickly they are consumed. But when heavy residues are used in the Diesel engine without reducing the size of the globules, only the surfaces of the particles are consumed in the short time allowed for combustion, with the result that the interior portion is converted into a pitchy substance which deposits on the surface of cylinders, pistons and valves, and produces waste of oil and clogging of the cylinder and valves. The oil entering the cylinder should therefore be completely atomized.

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[1] U. S. Representative, Carels Frères (Ghent, Belgium), 30 Church St., New York.

The resultant effect of an oil used in the Diesel engine depends entirely upon its heat value, and therefore with the same heat units per lb. an oil of 0.97 specific gravity will produce the same energy results in a Diesel engine as a lighter oil of 0.85 specific gravity.

The speaker further stated that although he has read now and then in the papers of 6000 and 12,000-h.p. Diesel engines built abroad, he found when he went to Europe that they were still all on paper; engines up to 3000 h.p. may, however, be built quite successfully. The speaker illustrated his remarks by several slides.

In connection with Mr. Haynie's discussion it was stated by one of the members that Baron Schmidt had taken out patents on a two-cycle valveless engine which is now built by Cochrane Company at Seraign, Belgium.

Professor Magruder, in replying to a question of Mr. Chubb as to the future possibilities of alcohol engines, stated that the best place to see alcohol engines in Europe is in the scrap heap. They are not a commercial success. The theory of these engines has been fully worked out, but as long as alcohol is heavily taxed, and the trade is throttled by commercial agreements, no real development along that line can be expected.

D. G. Baker remarked that the only way of producing alcohol at the present time is from some vegetable growth, and all that can be produced from the soil is required to feed the men and animals upon it. It is possible to use some waste products, e.g. waste molasses, to manufacture alcohol, but in comparison with the large volume that would be required for the supply of internal combustion engines, any such production is only a drop in the bucket. Mr. Baker also raised a question as to the exact amount of tar that can be produced from a ton of coal. This, according to the speaker, is an important matter, because coal tar is a smokeless fuel that might help to conserve the fast diminishing supply of anthracite, and it is in that direction that a source of relief for our future oil production must be looked for.

E. Y. Sayer supplied the information desired by stating that in this country 10 gal. of tar oil are obtained per ton of coal of 2000 lb. A member stated in this connection that where the production of tar is the main purpose of the operation, an even larger production has been secured by means of special processes, such as distillation at low temperatures, etc.

CEMENT MANUFACTURE

During the Annual Meeting of the Society one of the sessions on December 5 was given over to the discussion of the following papers contributed by the Sub-Committee on Cement Manufacture: Some Remarks on the Depreciation Factor in the Cost of Producing Portland Cement, Frederick H. Lewis; The Prevention of Missed Fires in Blasting, W. H. Mason; The Deterioration and Spontaneous Combustion of Gas Coal, Perry Barker. These, together with the discussion, are presented herewith. Certain of the closures are yet to be prepared.

SOME REMARKS ON THE DEPRECIATION FACTOR IN THE COST OF PRODUCING PORTLAND CEMENT

By Frederick H. Lewis, Birmingham, Ala.

Member of the Society

At the moment the question of the depreciation factor in the cost of producing portland cement is commercial rather than technical. Its urgent importance as a business proposition overshadows its scientific interest. The manufacturers of cement have so notably failed to define the cost of production, that few of them have a surplus or depreciation fund of any kind to deal with. In recent years numerous plants have yielded returns little if any greater than bare factory cost, and the commercial rating of the industry as a whole has suffered. The value which a technical discussion of depreciation may have, therefore, will consist chiefly in defining for the commercial end of the business the elements which should be considered to make up a satisfactory price for a barrel of cement.

2 The portland cement industry in America is but 37 years old. The first factory was built at Coplay, Pa., in 1875. This plant grew to considerable size and importance during the 25

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

years ending in 1900. But during the latter part of this period units of considerable size were one by one discarded as having reached the limit of their useful life. The early developments of the American, Atlas, Alpha and Lawrence companies were similarly discarded. It is the writer's judgment, based on personal observation only, that the average useful life of plant units discarded in this way did not exceed 10 years, and that it must have required 15 to 20 cents per bbl. to cover the depreciation factor. Fortunately at that time prices carried an adequate margin of profit.

3 It is quite likely that present plant is more nearly standardized and that it may suffer less from obsolescence. But this is not certain; and the simple fact is that we have no sufficient experience to justify this conclusion. The development of production has been so rapid during the seventeen years just past, that if we assume increased output to be directly represented by the new plant (which is not strictly true), then we shall find that the average age of the plant units which will produce this year's output is seven years. We have then no sufficient industrial history to establish our data. We are forced to exercise our best judgment.

4 Fifteen years ago an English manufacturer stated to the writer that the repair cost in the manufacture of cement would average six pence per bbl. (12 cents). Subsequent experience verified this to be a reliable estimate. Today the figure is probably nearer 15 cents because the mechanical equipment has been much elaborated in recent years. If it is assumed that the necessary capital required is $1.50 per bbl. of annual output, then the ordinary repairs in the manufacture of cement amount each year to 10 per cent of the entire investment. This is not depreciation; it has nothing directly to do with depreciation. It is ordinary repairs. Depreciation " is the necessary annual installment of the annuity which will amount to the first cost of the property at the expiration of its useful life." The cost of ordinary repairs is merely the first factor to be considered in estimating the useful life of the plant. The high cost of repairs indicates rapid depreciation, or a short useful life.

5 The second factor to be considered is obsolescence—that form of depreciation due to improvements in methods or in machines which makes it necessary to modify plant and scrap

machinery which is still in good running order. As already indicated we have little data in regard to this. It may be accepted as definitely true, however, that few plants could be successfully operated today with the equipment and arrangement they had ten years ago. The very few which might make such a claim, can do so only because either by chance, or by reason of greater foresight, they happened to be designed along the lines which later progress has followed. Plants which are now ten years old or more and which are still operated, have generally had large expenditures put into them for enlargements and for improvements in details; and in spite of this are operating at some disadvantage by reason of obsolete machinery. Kilns and power plants in particular have changed notably in design, and the economy of heavier machinery, and of labor-saving equipment has continually claimed recognition. Enlargements and modifications of plant have more often been forced upon manufacturers than desired by them. Enlargement beyond a certain point is no longer desirable, but has frequently been accepted as the only alternative to closing down the plant. Such forced enlargements represent, therefore, in considerable part, depreciation pure and simple, the gradual replacement of an obsolete plant which will be as gradually discarded. Yet the cost has in most cases been paid for out of new capital. The writer has not sufficient data to be able to express an opinion on the cost due to obsolescence during the period from 1900 to January 1, 1912. No one familiar with the facts will doubt that it has been large.

6 A third factor to be considered in estimating depreciation is loss of profits due to shutdowns for repairs and renewals. This is often a considerable sum, by reason of repair periods extending over three, four, or even six months. If there is no surplus fund to carry interest and overhead charges during such periods, then the business has not fully provided for the expenses due to depreciation.

7 There are then three principal factors to be considered in estimating a depreciation factor: (*a*) wear and tear; (*b*) obsolescence; and (*c*) the carrying charges during repairs.

8 The ordinary procedure of cement plants is to limit their cost data to a monthly cost sheet. This deals simply with factory cost and usually, and quite properly, with only a part of the factory cost. The real and only useful purpose of these monthly cost sheets is to enable operating officers to institute

comparisons, locate leaks, and cut down regular operating cost items. Unfortunately, and quite generally, the cement people have made the serious commercial blunder of regarding these factory cost sheets as really representing the cost to be kept in view when making prices. An immense industry has been rendered unremunerative for five years past by this unfortunate blunder.

9 A factory cost sheet to be useful for comparison of cost items from month to month and from year to year, should exclude all occasional or extraordinary expenditures. If items of this character were introduced at random as they occurred, the value of the cost sheet would be destroyed. Such occasional or extraordinary expenditures, which are really depreciation charges, must be provided for annually by appropriating a sum for plant renewals to be accounted for separately from the cost sheet. This appropriation can be an arbitrary one, or may vary from time to time as the superintendent's report may indicate the renewal requirements.

10 It is to be remarked here that it is usual to deal with depreciation as an annuity payment at compound interest. The propriety of figuring the annuity at compound interest for cement plants is open to question. A cement plant is not at all like the one horse shay which went to pieces all at once, and nothing first. On the contrary there must be a considerable annual depreciation fund for immediate use, and which can have no interest accumulation. Not to gainsay an accepted method, depreciation should be provided for in two items: (*a*) an annual plant renewal charge, and (*b*) a depreciation charge. The accounts of the U. S. Steel Corporation follow this method. There is a regular depreciation fund which is 3 per cent of gross earnings, and a construction or plant renewal fund of an approximately equal amount, but which varies more or less as earnings vary.

11 Coming then to a method of figuring depreciation, let us make the following assumptions:

- *a* Net capital investment = $1.50 per bbl. of annual output, or 1.5 cents per bbl. = 1 per cent return on the capital.
- *b* True depreciation to be based upon 25 years' useful life at 4 per cent compound interest. This equals 2.4 per cent per annum or 3.6 cents per bbl. of cement.

c Plant renewal to be based on 25 years' useful life, but without interest accumulation. This equals 4 per cent per annum, or 6 cents per bbl. of cement.

This basis assumes that each of the several items of the plant will be renewed once in 25 years, and that at the end of this period of 25 years the entire plant will have reached the end of its useful life. The writer is prepared to agree that this basis is low. But if the general argument is good, then the figures may be modified by exchange of views and data.

12 Assuming a factory cost of 60 cents per bbl., a remunerative selling price would then be estimated about as follows:

	Cents per Bbl.
(*a*) Factory cost including all ordinary repairs	60.0
(*b*) Depreciation fund	3.6
(*c*) Plant renewal fund	6.0
(*d*) Administration and selling expense, say	10.0
(*e*) Interest at 6 per cent on investment	9.0
Selling price	88.6

It will require about 90 cents per bbl. to come out even in this assumed case. It will require a higher average price if the business is to have a credit balance outside of depreciation.

13 On some such basis as this any manufacturer can estimate a safe selling price, using the actual facts of his own books for capitalization, factory cost, administration and selling expense, etc. If this is done most manufacturers will find that current prices have been too low in recent years, and still are so; many will find that an excessive capitalization must be scaled down if the business is to continue. And some will find themselves facing conditions which make it impossible to continue the industry.

DEPRECIATION AND OBSOLESCENCE IN PORTLAND CEMENT PLANTS

By H. Struckmann, Kansas City, Mo.

Member of the Society

To arrive at a fair percentage to be charged for depreciation, it is necessary to determine the probable average life of the machinery and buildings; this, however, is very difficult as in all cases there is a great deal of variation in the type of machinery and the character of material to be handled; furthermore, the rapid development of the industry has made it necessary to make continued changes and improvements in the plants and as a matter of fact has caused the depreciation, due to obsolescence to be greater than depreciation due to wear and tear.

2 The argument is heard quite frequently that if a machine is maintained in a state of efficiency by constant repairs and renewals of parts it does not depreciate so long as it does the work and that it is just as valuable when 10 or 20 years old as it was when new. The argument is wrong, however, as machinery does grow obsolete and cannot be made modern by repairs and renewals.

3 It is absolutely necessary to create a fund equal to the amount of the depreciation made from year to year and to be kept intact for the purpose of replacing the machinery and buildings at the end of their "life," and this provision should be made without any reference to profits or losses of trade, as depreciation for wear and tear and also obsolescence is a part of the working expense of a business.

4 The practice of showing so-called profits by accountants,

Extracts from a paper presented at the Annual Meeting, December 1911, and brought up for further discussion at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

out of which they create a depreciation reserve, without creating a fund as an offset, is dangerous, first, in that as a rule the amount of such depreciation is based upon the amount of the so-called profit, and secondly, in that it is wrong to make depreciation a charge on profits, as depreciation is positively a loss of the capital assets and should be made good out of the income or earnings, and finally, in that depreciation is as much a charge against revenue as material, labor, supplies, taxes, insurance, etc. The amount of depreciation should be determined without reference to the result of trading and must be considered as a charge in order that depreciation will represent the loss of value which occurs whether a business is conducted profitably or not.

5 The danger in not providing adequately for depreciation and particularly of basing it on the year's trading, is, that in bad years the amount which should be set aside for depreciation is paid out in dividends, which means in reality that dividends are paid out of the capital, a procedure followed as a rule with a view of better times coming when matters can right themselves; nevertheless this practice is always dangerous and invariably proves disastrous, as might be expected.

6 A large percentage of the cement mills of this country today are equipped with machinery which is out of date and is a serious handicap, but as provision has been made by hardly any of the manufacturers to replace their machinery, they must continue to operate old, and in some cases, obsolete machinery. Where the capital stock is raised for this purpose the new machinery quite frequently has to produce sufficient profits to pay interest on the lost capital as well as on the increased capitalization.

7 Over-valued machinery is a serious drawback to an operator in that if depreciation is properly applied it strikes at, and increases the producing cost by being burdened with more depreciation than should be applied if values were kept at the right figure, and from a financial standpoint this practice is most dangerous, so to be brief, depreciation must be defined as a loss in value which may be due to use, age or obsolescence, or a combination of these with several contributory causes and in a cement factory the amount of depreciation is the measure of loss in invested capital.

8 This may be called by some a pessimistic view, but in case of error it is error on the right side, as there is always the ele-

ment of unforseen contingencies which may happen at any time and for which a high rate of depreciation always serves as the best and safest plan of self-insurance for the manufacturer.

DISCUSSION

G. S. Brown[1]. There is bound to be a difference of opinion on the question of depreciation. Mr. Struckmann in his paper has taken the position that there should be a depreciation fund created in connection with portland cement plants. As to the correctness of this position as far as the ordinary manufacturing plant is concerned, there can not, it seems to me, be any question.

A cement plant, however, where both buildings and machinery are subjected to a very heavy wear, should be considered, from a very different standpoint than the ordinary plant where repairs are light and buildings are likely to last almost indefinitely. In the latter case any items of repair must of necessity come at long periods, while in a going cement plant the item of repair is continually before us, and it seems useless to consider a definite percentage of the original cost as a measure of the depreciation. The bulk of the investment in a cement plant is in the machinery, and one authority says: "If repairs are made so as to preserve machinery in first-class condition so that the work performed is of the same quality as when machinery is new, it does not seem equitable to charge off a percentage for depreciation."

This exactly describes the condition which must obtain in a cement plant if its output and cost are to be kept satisfactorily. Certainly no cement plant can compete today if the machinery in it is not kept in topnotch condition. It is, I believe, the practice with most manufacturers to take care of this by charging regularly each month to the cost of manufacturing all expenditures for the upkeep of the machinery and buildings, and as long as this is done there should be no need of additional charge for depreciation.

In a plant with which I am well acquainted there are machines which have been in continuous service for the last 15 years. These machines today do more work than they did 15 years ago. As a matter of fact, however, there is probably not a single part of the original machine now in service; indeed many parts have been replaced several times annually. Nevertheless from the standpoint of an appraiser, the machine is quite as valuable as a new one. Instances which show how the necessity for keeping machinery up to its maximum precludes the need of a depreciation account, are by no means as rare as the average engineer may suppose; indeed there are few machines in a cement plant not entirely obsolete, of which a similar statement may not be made. We realize, of course, that in the event of a mill discontinuing operations then the value of the plant has depreciated enormously. Few companies, however, would be willing to carry a depreciation account on their books sufficient to reduce the value at which a going plant was carried to a sum which would represent its value in the event of its no longer being operated.

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[1] Alpha Portland Cement Co., Easton, Pa.

When, however, the question of obsolescence enters we have a very different condition, particularly in a business where there is as yet no standard practice and no standard machinery. Machinery considered modern today is obsolete tomorrow and the only possible way that a mill can keep in competitive condition is ruthlessly to dismantle machinery which has become obsolete and replace it with more economical modern machines. It hardly seems possible that so large a percentage of plants as Mr. Struckmann cites can be operating in the present condition of the industry with out-of-date machinery. If the statement is approximately justified by facts, we must expect a very large number of receiverships and bankruptcies in our industry within the next few years.

The question of how the expenditures for renewing obsolete machines and buildings shall be handled is no doubt a very difficult one to the average concern. The amounts involved are necessarily large and to charge the entire amount at once to the cost of manufacturing seems, at least from the operating standpoint, unjustifiable. Particularly is this so with those concerns where only a single plant is operated and where the charges for replacements of this sort run into a considerable amount of money within a very short period of time. To carry such expenditures in a capital account, however, will be very strongly opposed by modern accountants and our judgment coincides with this attitude.

The fact that charging such expenditures to the cost of manufacture increases this item unreasonably and unjustly in particular months has led many corporations to put on their books accounts such as Improvement Account, Extension Account, Renewal Account, etc., with the result that ultimately the sum carried on the books as the value of the plant has been increased to an unwarranted degree. Some cement companies have a rule which requires that any expenditure for machinery or buildings which in any way replaces those heretofore in service, irrespective of whether the new machinery increases output or not, must be charged to repairs. When this rule is invariably followed the question of obsolescence must be satisfactorily cared for, although many experts will insist that an adjustment be made transferring a percentage of the expenditures to capital to equate for any increase of output or decrease of cost. The above method is open to the same serious criticism that it increases the cost abnormally at certain times and does not give a fair opportunity to compare them from month to month.

It has always seemed to me that the most reasonable method for handling the replacement of obsolete machinery is to have a certain specific charge made monthly to the manufacturing account against every barrel of cement manufactured, this charge to be more than sufficient to take care of, in the course of a year, those expenditures which experience has proved must be made annually in order to replace machinery which has become out of date. Against the fund which would be derived from this course would be charged all expenditures for renewals, and in this way the result obtained would be exactly the same as if all such charges were originally made to the manufacturing account. The effect would be, however, to distribute these charges more uniformly throughout the year, and give a very much more satisfactory cost for the purpose of comparison. Any system of accounting, however, which considers any portion of the repairs, or the expenditures for the replacement of obsolete machinery and buildings as capital expenditure, will ultimately cause trouble for those who manage the concern. I know of no plant where the method of handling expenditures for renewals just outlined is being followed, but feel sure that it would be more satisfactory than any other of which I have any knowledge.

As Mr. Struckmann has said, the question of the obsolescence of cement plants must be faced by every manufacturer of cement, and any attempt to straddle the question will result only in a postponement of the day of reckoning.

Entirely apart from the mill proper, in every cement producing plant there is an item of depreciation which must be considered, and that is the depreciation of quarry. Many plants are so situated that this item can be entirely overlooked. The quantity of raw material at hand is so large that for practical purposes it may be considered unlimited. Other plants are situated, however, where the body of raw material is circumscribed, and in such places it is very necessary that a proper depreciation account should be opened to replace the raw material at the expiration of a certain fixed time.

R. K. Meade. At the plant of the Tidewater Portland Cement Company, Union Bridge, Md., all the machinery, including conveyors and elevators, is driven by individual motors. The central power plant consists of three 23 by 46 by 48 in. compound condensing Corliss engines made by the Wisconsin Engine Company, and direct connected to General Electric 800-kw. generators supplying 3-phase current at 550 volts and 25 cycles; a reserve 150-kw. unit is also at hand. A frequency meter is installed to control the cycles and by them the speed of the mills. To control the efficiency of the power plant independently of that of the whole system, a recording meter is installed and, in combination with automatic coal scales, gives all the information required.

Throughout the mill itself recording watt-meters are installed in the various departments. This allows a record to be kept of the power used in each department. Readings of these are taken twice a day, with the change of shifts, and any unusual rise in power per barrel in the department is looked into at once. This results in low power consumption because as soon as a rise occurs, it is instantly traced to its source. When the mill was first started, a great deal of trouble was experienced with the motor drives. Most of this was due to faulty arrangement. In some cases, the motors were much too small for the load on them, and in others, large motors were pulling very light loads. The result was that the large motors were running at a very low load factor and the small motors were giving a great deal of trouble from overheating and even burning out. In order to remedy the trouble a test was made of every motor on the plant when operating under normal conditions, and, as the result of this test, a re-distribution of the motors was made, and in all about 40 motors were changed. Much of the trouble with the motor drives was thus eliminated. In changing from a line drive to a motor drive and in installing a motor drive in a new plant, much thought should be given to the size of motors employed. When the Tidewater was built very little information was available relative to the horsepower required by conveyors and elevators operating in cement mills and most of the locating was done by guess rather than by science. Manufacturers generally are apt to underestimate the power required by their machinery. At the same time, if too liberal allowances are made over their figures, and motors much too large are employed, the result will be a low load factor, and the need of additional generating machinery in the power plant or the use of a few synchronous motors about the plant.

One objection to the employment of small individual motors for a group of elevators and conveyors is that the small motors are likely to stall from an overloaded conveyor or elevator, while with the larger motor the surplus power is sufficient to overcome this overload. This point against the individual drive, however, is to my mind, more than offset by the absence of belting and countershafts in the mill.

At the Tidewater plant, the conveyors and elevators are all driven by back geared motors of the squirrel cage type and the writer's experience with these extends to motors up to 30 h.p. The gears and pinions after a year's service show almost no wear. The gears are encased in a dustproof gear case, which is partly filled with a cheap grade of heavy oil. The power is transmitted from the motor to the conveyor or elevator by means of a sprocket and chain.

The Fuller mills at Tidewater are all driven by vertical motors. The 42-in. mills are driven on the raw side and in the coal mills by 75-h.p. motors and the 54-in. "Dreadnaughts," on the clinker side, by 200-h.p. motors. The 200-h.p. motors were the first vertical motors of this size ever built and at first gave some trouble because of improper lubrication, which has been remedied. Experience has shown that it is far superior to the old quarter twist belt formerly employed with mills of the Fuller-Lehigh and Griffin types.

At Tidewater the motors driving the Fuller mills are installed with indicating ammeters which are placed in full view of the mill attendant and when the indicator on the ammeters to the 200-h.p. motors points to 175 amperes, the attendant cuts off the feed to the mill and so avoids a choking of the latter.

A compressed air line runs from the compressor in the quarry to the mill, with branches to various departments. This is used for blowing out the rotors which are for this purpose lifted out of the motors by means of an overhead trolley and chain block. The motors are protected by no-voltage and overload relays.

The system followed at Tidewater of taking care of the motors is as follows:

The motors are in charge of men appointed for that purpose and known as "motor-men." It is their duty to start all motors after a shutdown for repairs or for a choke in the mills or elevators. This avoids burn-outs. They also make thermometer readings of every motor once a day and inspect the motors hourly. At the end of the day, they make a written report of the condition of each and every motor in the plant and advise what repairs, if any, are necessary. They also give the number of hours each motor was in operation during the shift and report on all shutdowns, stating whether these were due to the motors or to the machines they were driving.

This enables an exact history of each motor to be kept and for this purpose each is given a number, starting with zero. All records are kept in a special ledger known as the "motor ledger," a page being devoted to each motor. At the head is placed the plant number and the figures obtained from the manufacturer's name plate as to type, rating and shop serial number. Any repairs are charged on this page and at any time an exact figure as to the cost of upkeep of any motor can be obtained from this ledger.

Table 1 gives a list of the motors at the plant of the Tidewater Portland Cement Company, as arranged, September 15, 1912.

TABLE 1 MOTORS, TIDEWATER PORTLAND CEMENT COMPANY
As now Arranged for 300 Bbl. Daily Capacity

Machine	Motor. H.P.
Air compressor	100
Incline chain hoist for cars	22
Car dump	12
Limestone crusher, No. 9, gates	150
Limestone crusher (2) No. 6, gates	50
Pan conveyor from the above, back geared	5
Elevator from above to dryer stock boxes	20

TABLE 1—Continued

Machine	Motor, H. P.
Belt conveyor from above to stone storage, back geared	5
Belt conveyor from limestone storage, back geared	5
Shale crusher, No. 6, gates	50
Pan conveyor from above, back geared	10
Elevator from above to stock boxes above dryer, back geared	15
Screw conveyor above dryer stock boxes, back geared	10
Belt conveyor to shale storage, back geared	5
Belt conveyor from shale storage, back geared	5
Limestone dryer 7 ft. in diameter, and 50 ft. long	30
Shale dryer 7 ft. in diameter and 50 ft. long	15
McCaslin conveyor, limestone, back geared	10
McCaslin conveyor, shale, back geared	10
Ball mills, Krupp No. 8 (3)	50
Elevator from two limestone ball mills to mix bins, back geared	20
Elevator from shale ball mill to mix bins, back geared	10
Screw conveyor from mixing bins to scale, back geared	10
Screw conveyor from mixing scales to elevator, back geared	10
Elevator from above to the pulverizer stock boxes, back geared	10
Fuller mills, 42 in. (8) raw materials, vertical (8)	75
Fuller mills, 54 in. (2) raw materials, vertical (2)	200
Screw conveyor from mills, back geared	5
Rotary coolers, 5ft. diameter and 40 ft. long, back geared	10
Screw conveyor over pulverized bins, back geared	10
Screw conveyor from kiln stack dust chambers, back geared	5
Fans, motors are direct connected, high speed	10
Screw conveyors feeding pulverized coal to burners, back geared	2
Kilns, 8 ft. in diameter and 125 ft. long, variable speed	30
Rotary coolers, 5 ft. diameter and 40 ft. long, back geared	10
Inclined pan conveyors from kilns, back geared	5
Belt conveyor from above, back geared	5
Elevator from above, back geared	10
Belt conveyor from clinker storage, back geared	7½
Belt conveyor under clinker storage, back geared	10
Bucket elevator from gypsum, back geared	5
Elevator from clinker and gypsum scales, back geared	20
Fuller mills, 54 in. clinker (10), vertical	200
Screw conveyor from below to bins in stock house, back geared	10
Belt conveyor to stock house, back geared	10
Screw conveyor from bins, back geared	30
Elevator from above to packing machine boxes	7½
Bates valve baggers (two on one motor)	30
Bag tying machine	2
Belt under coal trestle, back geared	30
Crushing rolls and elevator from above, back geared	5
Ruggles-Coles dryer, coal, back geared	7½
Elevator from dryers, back geared	7½
Meade dryer, coal	10

TABLE 1—Continued

MACHINE	MOTOR, H. P.
Fuller mills, 42 in. coal (3), vertical	75
Elevator and conveyor from above, back geared	10
Coal tunnel at power house conveyor, back geared	5
Elevator from above, back geared	7½
Drag conveyor from above, back geared	10
Stokers in boiler room (all on one motor), back geared	10
Machine shop (entire equipment)	15
Bag cleaning wheel	15
Motor driven exciter	150
Hydrated lime plant (entire equipment)	100

R. C. CARPENTER stated that he made a very careful study of many of the points in this paper. The percentages of selling price as figured out, is practically 50 per cent more than the manufacturing cost. He does not believe that there are many manufacturers outside of the cement industry that can ever make money with a selling price not more than 50 per cent greater than the cost of production. That percentage seems to be a very low amount for overhead charges, administration, interest and depreciation. If what Mr. Lewis states is correct, the earnings in the cement industry do not look so unfavorable as compared with other industries. Professor Carpenter has found that in proportion to the amount invested in the business the net earnings of the cement plants were smaller than could be found in a good many industries. This seems to indicate that there has been a very great competition in the cement industry, and that prices have been as a whole too low. Of course for a few years mills may be operated, although the returns may be small, but in the long run the capital invested in any industry whatever must receive a certain net return. The speaker's investigation rather indicates that for the last few years in the cement industry the returns have not been adequate for the investment; he believes that it is fair to the producer that prices should be raised, and thinks that they could be raised without affecting the demand.

As to obsolescence, the speaker pointed out that in the cement industry, grinding machinery, for instance, had a remarkably long life, both in view of the time that it has been kept in use, and of the improvements in that kind of machines. In regard to kilns there has been a very great change due to improvements in the last few years. On the whole he is more in accord with Mr. Browne in his discussion than with Mr. Lewis. The grinding mills have a long life, but to keep the machines in running order a large and constant repair account is necessary. His important question is whether this large repair account should properly be charged to depreciation, or to the operation of the plant. Professor Carpenter thought that the proper way to find the true depreciation was to ascertain whether the amount charged for that purpose made the capital account really different from its true valuation. If the plant becomes of less value year by year, and there is no money to cover this loss, then there is a depreciation which has not been taken account of.

There should be an increase in cash corresponding to the loss in value, if the depreciation is taken care of, and if the value of the plant is not kept up to the original cost. The depreciation may be accounted for, as Mr. Browne states, by an actual charge per barrel against manufacturing cost.

R. K. Meade raised the question of the relation between the sinking fund and depreciation account; if a plant is built with bonds, and charges off every year for sinking fund, should it maintain also a depreciation fund? As regards the question of obsolescence with particular regard to the cement industry, then one had to do more with the problem of turning out cement in very much larger quantities than with actual changes of process. In some cases, especially in the West, the question of the supply of raw material, particularly limestone, is also of importance.

P. H. Wilson[1] claimed that Mr. Lewis was wrong in stating that the net capital invested is only \$1.50 per bbl. In most cement mills in the United States it runs between \$2 and \$3 per bbl., and if his calculations are taken on the basis of \$2.50, there will be added considerably more than 50 per cent to the net cost of depreciation and of selling a barrel of cement. As to interest, Mr. Lewis estimated it at 6 per cent on the investment. The figures should be pretty nearly doubled, with exception of the administration or selling expenses, which are not affected by the capitalization of a mill to prove an attractive investment.

A few years ago Mr. Mallory made up some interesting figures on the cement industry in the United States, and found that this industry turned its capital over at a less rapid rate than any other industry in the United States. It takes the cement man about three years of actual work to turn over his capital and therefore, instead of the interest being charged at a flat rate, it should be increased to cover the fact that the capital is turned over so slowly.

Joseph Brobston explained that while the amount of stocks or bonds issued on a plant may be $2 or $3, the amount of money really invested per barrel is very conservatively estimated by Mr. Lewis at $1.50, the great trouble with the industry being that in many cases plants have $2 or $3 per barrel capitalization, due to the fact nothing has been charged off for depreciation, and all replacements of machinery have been added to the capitalization. If a sinking fund were maintained, as suggested by Mr. Meade, that would take care of a part of the depreciation charge, and by the time it was necessary to replace the machinery, the bonded obligation would be reduced to such an extent that more money could be obtained without over-capitalization. Ten cents per barrel should cover both depreciation and obsolescence, but at that figure the machinery would have to be kept in good order all the time, with the repairs being charged into the monthly cost.

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[1] Secy., Amer. Portland Cement Mfgs., Land Title Bldg., Phila., Pa.

To arrive at a proper depreciation charge one should start in at the quarry. There are some plants where the cost of replacing their stone would be practically a negligible item, but a great many companies have a limited supply, and these companies should charge off the amount it would cost to replace it, and not what the land originally cost. The next step is to have competent builders determine what the depreciation should be on the class of buildings in the plant. Figures for the depreciation of the engines, boilers and motors could be easily secured; the actual depreciation on the latter could not be included in the monthly charge for repairs because the motors go on without much repairing until they are thrown out entirely. There is probably a good deal of depreciation in the kiln room. The speaker thinks that a 6 by 60 ft. kiln would be rather a handicap today, the 8 by 125 probably being better adapted to the present economic conditions.

Mr. Wilson stated that although some cement manufacturers are beginning to use concrete and reinforced concrete in their mill buildings, the increase in sizes of the newer plants have come so rapidly that there is a tendency not to use material of too permanent a character, and this may be expected to continue for the next five or six years, because the economic size of the kiln and the life of the grinding machines are not absolutely fixed at the present time, and perhaps will not be for some five or six years to come. But wherever they have put in storage houses, reinforced concrete was used almost entirely.

A very important point brought out by Mr. Meade is that power at the Tidewater plant is generated at far less than half a cent. The cheapest price of power in the Lehigh Valley is about a third more. How long a plant can continue to generate power at $33^1/_3$ per cent more than another plant and do business, the speaker did not profess to know.

F. W. Kelley supported the suggestion that if different manufacturers compared notes, they could get some definite figures on depreciation, and spoke of the work being done by the Society in the appointment of sub-committees on industry. The Sub-Committee on Cement Manufacture is endeavoring to secure information from other sub-committees of the Society on the depreciation and obsolescence of the various machinery entering into power plants, electric motors, lineshafts, pulleys, wiring, etc. Thus far no data have been received, but when they come, they will probably be of great value.

R. C. Carpenter commented on the remarkably low result obtained by Mr. Meade, of 3.3 lb. of coal per kw-hr., as showing exceedingly good management as well as the use of the best kind of machinery. A 5000-kw. turbine which he had investigated some time ago had given a result of 2 lb. of coal per kw-hr. with West Virginia coal. This was thought to be a record result at the time, although higher economy has since been obtained. As the load changed, however, the economy changed very materially in that test, and as the load varied from the best, more coal per kw-hr. was used. This result indicated that Mr. Meade had his turbine running with about the best load and that his transmission losses were exceedingly small. Generally the cement industry presents opportunities to get high economy, as machines can be run at practically a constant as well as full load.

E. Y. Sayer called attention to the advantages of standardizing the motors used in cement mills, by having the motors go in units of 5, 10, 25 and 50, in order to facilitate repairs. He also highly commended the system used in the plant described by Mr. Meade, viz., an assignment of special men to look after motors, daily records and reports on each motor, special men for starting motors, etc.

H. Struckmann. Mr. Lewis' remarks on depreciation in cement plants are very apropos at the present time. Even in territories where an actual cement shortage exists, prices are kept at a ruinous level, the only explanation for which is that the manufacturers, as Mr. Lewis states, have failed to define all of the items entering into the cost of producing portland cement.

At a recent meeting of the Association of American Portland Cement Manufacturers, the writer brought up the question of proper depreciation charges, and suggested a minimum of 0.10 per barrel, which, according to Mr. Lewis' views would be equivalent to about 7 per cent of the capital invested in the plants. The fact that the current repair charges in a cement plant amounts to between 20 and 25 per cent of the total manufacturing cost, indicates clearly that the depreciation going on is considerably higher than in the average industrial plant, and that if anything, 7 per cent on the invested capital, or 10 cents a barrel is too low a charge to cover depreciation.

The following classifications of depreciation charges, which are adopted in the plants with which the writer is connected, may be of interest:

	Per Cent of Reproductive Value
Factory buildings	5
Factory machinery	12
Power plant equipment	10
Electric light system	7
Railway tracks	7
Quarry rails and equipment	15
Tools and fixtures	10
General construction, fences, retaining walls, etc	7
Water works and pipelines	10
Oil storage tanks	7
Dwellings	5

The above various percentages represent on the basis of capital invested per barrel output, as outlined by Mr. Lewis, approximately a flat rate of 15 cents per barrel, and the writer's experience has shown that it is none too heavy a charge if the investors in portland cement plants are to be protected.

Mr. Lewis' statement that carrying charges during shutdowns of the plant on acount of repairs are properly chargeable to the depreciation fund, in the writer's opinion, is not correct. Interest, overhead, as well as other carrying charges of similar nature, have nothing to do whatever with depreciation and should be taken care of not by the depreciation reserve fund, but by a contingent reserve fund, created not only to take care of the above items but also to cover charges accruing while the plant is idle on account of the market conditions, as well as extraordinary accidents like explosions, floods or other causes beyond control.

THE PREVENTION OF MISSED FIRES IN BLASTING

By W. H. Mason, Stewartsville, N. J.

Member of the Society

A frequent cause of serious accidents in cement manufacture is the explosives used in the quarries. Many of these are due to what is commonly called "missed fires," that is, bore holes which have been loaded with explosives and which fail to explode when detonated. Formerly when the holes were exploded by time fuses this was probably more frequent than at present, when it is common practice to explode a series of holes by an electric battery, fuses being used only to explode the small "plug holes" or dobies, for the purpose of breaking large stone which has already been blasted from the ledge.

2 A "missed fire" is always a source of danger. There is no known way of unloading it safely and when an attempt is made to drill another hole near it, so as to blast it out, the drill bit not infrequently comes in contact with the dynamite in the loaded hole with disastrous results to the driller. When the driller is fortunate enough to get his hole in without accident, it is loaded and blasted. This usually throws the powder from the "missed fire" hole among the debris and frequently when the latter is being loaded, a laborer will strike it with some tool and cause an explosion. The only way to avoid this danger is to prevent the missed fires. Newspaper clippings collected by the Du Pont de Nemours Powder Company show that there were 59 people killed and 157 injured in the United States in the last three years, due to missed fires.

3 For about eight years the Edison Portland Cement Company have been exploding all churn drill blast holes with a 500-volt direct-current power circuit. Many of these blasts are

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made of from 12 to 20 holes, each loaded with 500 to 800 lb. of 40 and 50 per cent gelatine powder, and during this time there has been only one missed fire hole. It was impossible to find the cause of this failure, but it was attributed to a poor connection from the exploder leads to the bus wires. Before this time, they had been using the common push-down batteries and it was a usual thing to have several missed fire holes per month.

4 One of the quarries of the company is so located that no power circuit is available. For a year or two the blasts were set off by push-down batteries. After having had several missed fire holes, and some resulting accidents, they installed a small 250-volt direct-current generator, driven by a steam turbine. This has been in operation several years and there have been no missed fires since its installation.

5 Gelatine powder is the most difficult of all the dynamites to detonate and it is a well-known fact that if exploded by a powerful detonator, the full effect of the powder is obtained, while if improperly detonated, much of the effect is lost. For this reason and also on account of the danger and expense which always accompany a missed fire hole, the writer believes it is well to use too many exploders, or electric fuses, of high power than not enough. In a 6-in. bore hole, running 60 ft. deep, not less than three exploders should be used. One of these should be directly at the bottom, so that if when loading the hole with dynamite, a stone should slide in from the side and block it off, it would still be possible to explode the dynamite below, and thereby avoid the danger from the otherwise unexploded dynamite; the other two are distributed one near the center and the other near the top. All are connected directly across the 500-volt or 250-volt direct-current line, so that all exploders are in parallel and receive the full voltage of the power circuit. By this method any number of holes may be exploded at one time.

6 The cost of the extra exploders is always a small proportion of the cost of the dynamite used and the writer believes that this expense is warranted by the increased detonation power of the exploder, as well as by a sort of insurance against missed fires, which are always expensive aside from their potential danger.

7 Fig. 1 shows the method of connecting the wires of the electric fuses to the bus wires. The argument has been advanced

frequently that the insulation on the leads of the electric fuses is not sufficient to withstand the high voltage. This, no doubt, is true, but experience shows the fuse in the exploder blows

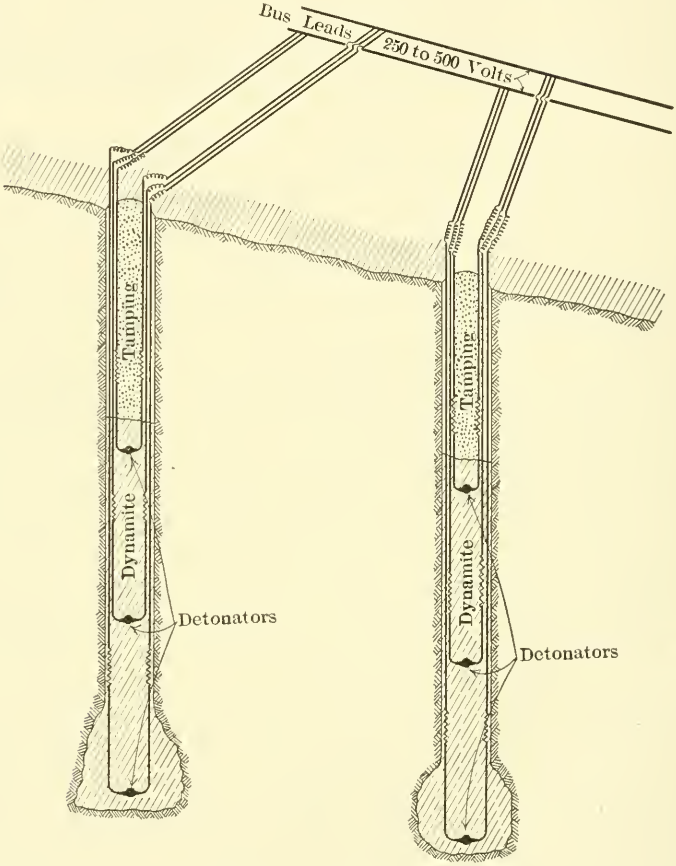

Fig. 1 Showing Exploder Leads and connections to Bus wires

while the insulation is breaking down, and it is then a matter of no importance whether the insulation fails or not.

THE DETERIORATION AND SPONTANEOUS COMBUSTION OF GAS COAL

By Perry Barker, Boston, Mass.

Junior Member of the Society

In the storage of coal for use in cement manufacture the risk due to spontaneous combustion must receive serious consideration. Spontaneous combustion is caused by slow oxidation, principally of carbon compounds in an air supply, which is sufficient to support the process of oxidation but not sufficient to remove entirely the heat thus produced. The majority of cement manufacturers use gas coal slack for burning; having an average analysis as follows:

Moisture	3.00
Volatile matter	33.50
Fixed Carbon	55.50
Ash	8.00
	100.00
Sulphur	1.50

2 While the amount or composition of the volatile constituents of coal, or of the percentage of sulphur, give no direct indication of the liability to spontaneous combustion, fuels of this type have been known in a number of cases to heat in storage to such an extent that ignition and serious damage due to fires have resulted. The total loss of heat value due to storage without spontaneous combustion is comparatively small. However, the results of deterioration which has proceeded to the ignition point are more serious, involving the change in the character of the coal due to loss in volatile matter, abnormal percentage of moisture contained in the fuel after quenching as a last resort, costs of moving the coal in an endeavor to arrest the spread of the fire after the coal has become heated

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in certain localities in the piles and financial loss from fires directly traceable to this cause.

3 A number of erroneous reports have been submitted as to the extent of loss in heating value due to the deterioration of coal exposed in storage. These reports contain various figures on the loss in heating value, ranging from 10 to 50 per cent. Some results of tests on German gas coals have been submitted which state that these fuels have sustained an average loss of 1.7 per cent of heating value per week.

4 The diverse nature of the data which have been published on this subject, together with the importance of the subject, have promoted extensive experiments by the U. S. Bureau of Mines, the Illinois State Engineering Experiment Station, and several private interests to determine the exact nature of the reactions involved and study methods for prevention. The processes of deterioration from which spontaneous combustion ultimately results may be best stated as follows:

a The escape of combustible gases when fresh surfaces of coal are exposed after removal from mine workings. Experiments on coals having the analysis described indicate that the loss of combustible gases in this manner is approximately equivalent to the volume of the coal. The heating value of these gases amounts to 0.1 to 0.2 per cent of the calorific value of the coal. The detrimental feature of this action does not lie in the small loss in fuel value but in the dangers incurred by the escape of inflammable gases in mines and the oxidation which accompanies the evolution of these gases.

b The absorption of oxygen from the air with consequent evolution of heat. This reaction is conceded to be the primary factor in the process of coal deterioration and production of heat in piles and is caused by the direct union of the oxygen of the atmosphere with unsaturated carbon compounds in the coal matter. Freshly mined coal is very susceptible to this reaction and absorbs oxygen with great avidity at the time of evolution of combustible gases.

c The size of coal, particularly of the type used for cement manufacture, is a primary factor in promoting deterioration. Fine coal brings larger surface exposure in contact with the atmosphere and accelerates the process of oxidation in the entire mass.

d The presence of moisture in abnormal percentages, particularly if coal in storage is wet and dried alternately, accelerates the processes of absorption and oxidation. The extensive experiments by the Illinois State Engineering Experiment Station have shown that the activity of these reactions is increased by wetting the samples under test.

e External sources of heat, even though moderate in degree, tend to promote the reactions which produce spontaneous combustion. Heat produced by external sources may originate from contact with steam pipes, boiler walls or floors. This heat may also be traceable to the climatic conditions.

f The importance of the oxidation of sulphur compounds in the process of deterioration is a question of some contention among the authorities on this subject. Although the total heat evolved from this source is not large in comparison with that produced by the several sources noted above, it will undoubtedly promote to some extent the other reactions.

5 A number of experiments have been conducted upon high volatile American coals to determine the actual loss in heating value during storage, together with observations on the slacking or reduction in size produced by the deterioration. Universal opinion is now to the effect that such coals will lose from 1 to 3 per cent of their heating value in one year. A large percentage of this loss results within from three to six months after the coal is placed in storage. It is apparent that the loss in heating value is not the most serious consideration in the question of coal storage. However, the ultimate results of deterioration which has proceeded to the ignition point, although not determinable in financial units, demand that certain precautions be taken to prevent the procedure of this action to a point where ignition will result. The methods of prevention can best be divided into the following general headings:

a Elimination of combustible gases before storage.

b Storage in piles not over 10 or 12 ft. deep with maximum points the same distance from exterior of storage.

c The removal of fine coal so far as possible, storing only the screened lump. If a mixture of lump and fine coal is stored the various sizes should be evenly distributed to prevent the formation of air passages through segregated portions of large sizes.

d Ventilation by pipes should not be attempted and the admission of air by infiltration through brick work or porous foundations should be prevented.

e Exposure to weather conditions, where the coal is subject to heavy rains and subsequent drying from the sun or other sources of external heating such as steam pipes or heated brick work, should be avoided.

f The elimination of heating by the prevention of action through submerged storage. The effect of a large percentage of moisture introduced by submerged storage has been materially lessened in a plant recently constructed in which coal is stored but partially submerged. It has been found that the exposed portion of the piles maintains a sufficiently high percentage of moisture through capillary attraction to prevent serious oxidation.

g Prevention of dangerous dust and gas explosions as well as spontaneous heating caused by the storage of powdered coal. Coal for burning clinker should be pulverized at the furnace doors and only at the rate required for immediate use.

6 While the extent of the loss in heating value through deterioration of high volatile American coals, such as are used in cement manufacture, may not be of serious importance, the heating effects of the reactions incident to this deterioration demand attention to the designing of coal storage and to the necessary procedure in arresting deterioration which has begun through lack of proper precautions.

DISCUSSION

E. Y. Sayer referred to a recent bulletin issued by the United States Government on the deterioration of gas coal and stated that the facts set forth in this bulletin indicated that the depreciation taking place in gas coal was very rapid at first, commencing immediately after the coal was first mined, but the rapidity of deterioration was greatly reduced as time went on, and after a year or so it became almost a fixed quantity.

If this is the case he thought that a great many companies were making a mistake by periodically or at frequent intervals using up their storage. It would seem that storage should be looked upon as merely a matter of insurance and that after a sufficient amount of coal had been placed in storage it should not be used until absolutely necessary to draw on it. Every time that coal is taken out of storage, we are simply pocketing the loss due to the early rapid depreciation; whereas, if the coal is allowed to remain in storage, this loss will be incurred only at long intervals of time.

The AUTHOR in answering Mr. Sayer's questions, stated that, if a pile starts to fire, the first alternative would undoubtedly be turning over, provided the combustion had not proceeded to such an extent that it was impossible to get close enough to the source of heat. He had found a number of pile fires where the coal had become incandescent, and there the only alternative was flooding. The method of using closely covered storages in order to prevent spontaneous combustion the speaker found to be a very dangerous one. A fairly large volume of CO_2 would be produced with the possibility that the process of heating would proceed to such an extent that large volumes of combustible gases would also be liberated, leading to explosions. He cited a case where fire was caused by closely covered storage. A pile of ten or twelve thousand tons of coal, of exactly the character now under consideration was placed in outside storage. Snow fell to the depth of say two or three inches and instead of leaving the coal which was already covered with snow open, the whole storage was covered closely with rough lumber, laid tight to the pile, and down to the ground, with the result that there was no ventilation whatever. The coal was wet, and serious fires started.

Another of Mr. Sayer's suggestions was that, from a commercial standpoint, storage should be looked upon as a matter of insurance. The stored coal should not be used up until it is absolutely necessary to draw on it, because the greatest deterioration takes place in the first few days after the coal is mined, and changing the coal in the storage often means simply pocketing the loss due to the yearly depreciation. Mr. Barker pointed out, however, that it is very dangerous to leave coal in storage for a great length of time. The two problems of deterioration and spontaneous combustion, while interdependent, are somewhat different. The loss in heat values may proceed rapidly in freshly mined coal, and ultimately reach a minimum, but an action may have been started to such an extent that it will proceed violently with resulting ignition. Besides, as shown in the paper, there is depreciation in the actual gas making value of coal when placed in storage.

The question of moving coal which has reached a certain temperature is of great importance. A temperature of 140 to 150 deg. fahr. is considered sufficient cause for taking steps to move the coal, preferably digging a trench of such width and length that the source of the high temperature can readily be exposed without covering it with any fresh coal.

During the presentation of his paper, Mr. Barker referred to the subject of fires and described a method of determining the temperature at the interior of a pile by means of a ¾-in. auger containing a maximum thermometer. The auger is screwed to sections of iron rod of slightly smaller diameter and can be driven in the pile to a distance of about 20 ft. and it requires about 20 minutes to record a maximum temperature. The result with lump coal is not very successful, but with the Eastern Pennsylvania bituminous coals that come to the market it afforded a ready means for driving the thermometer to the source of the trouble.

In reply to a question, Mr. Barker stated that the possibility of the heat produced by frictional resistance in driving the auger into the coal affecting the amount registered by the thermometer had been fully considered. It seemed, however, to be a factor of little consequence, because the auger is driven at the rate of 20 ft. in two or three minutes. Mr. Sayer suggested that this question could be settled fully by inserting an auger in a pile of coal of which the temperature is precisely known; then the recording thermometer in the auger would show just what happens.

MISCELLANEOUS DISCUSSION

THE PRINCIPLES OF VALUING PROPERTY

By Henry K. Rowell, Published in The Journal for September 1912

ABSTRACT OF PAPER

The purpose of the paper is to bring out some of the fundamental principles involved in the valuation of property. The distinction is defined between the word value, and a valuable consideration, and the several purposes for which value is to be determined, each of which may vary from the other and still be within the truth. The commercial value is the one most essential to an industry and should be the determining factor for purposes of tax, insurance or sale.

No valuation can be properly ascertained without accounting for the depreciation.

Capitalization is a delicate and intricate question to deal with. The author's experience is that most if not all writers skip over this subject lightly, and he has yet to find a real logical discussion of the subject.

In all mechanical and industrial processes the same laws of growth and development are as potent as are the laws of evolution in the natural growth and development of the physical world.

DISCUSSION

Charles H. Fish. The question of the valuation of property, speaking particularly of manufacturing property, is one which, unfortunately, can be looked at from a number of points of view, all of which are more or less reasonable. The answer to an important question always asked as to the age of a machine, a group of machines, or a building, is apt to be misleading. There is a number of kinds of machines which have been but little improved upon during the past period of years, and on account of this slow advance in the state of the art, the age alone is of comparatively small importance. Again, the question as to how carefully or intelligently the repairs have been kept up is one that must be considered in determining the present

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

value. To quote from Mr. Rowell, Par. 46, "The writer has known frames of about this age (15 years) to require such thorough fitting that the standards were about all that there were left to the original machine." In other words, when the repairs were finished, these frames had new roll stands, new rolls, new spindles and rings, or in fact all of the important operative parts of the machine had been renewed. Admitting that the design of these machines was good, as no doubt it was, did they not, by these repairs, practically wipe out 15 years of age with which these frames were charged, bringing them down somewhere near a new frame age?

At the same time, in a recent experience with an association of insurance companies, the writer found it very difficult to get them to depart from the old theory that all machines have a certain, more or less definite life, at the end of which they were practically dead and worth only their value as scrap, and following this theory, they claimed that a machine, the life of which was called 20 years, was half worn out at the end of ten years. There are many machines in textile mills that are of such design or their operation of such character, that their active life can, by intelligent repairs, be continued almost indefinitely. These machines may die at the end of 20 years if allowed to by neglecting repairs, but as a rule they are well, or at least fairly well, kept up. On the other hand, it is a fact that some machines are bound to wear out in spite of attempted repairs, or many become worthless owing to new improvements and inventions, but to state that the life of a machine or a building is a stated period of time, or that its value depreciates at a definite percentage per year, is very often wrong.

One of the principles of valuing property should be a careful detail investigation of each part or portion of the property in order to determine its actual physical condition and not to be guided too much by the one factor "age."

In reply Mr. Rowell said it was his intention to bring out here what might be called secondary depreciation. At the end of a period a machine, or group of machines, might be revived so as to be comparatively new, yet they were not as good as wholly new modern machines would be on account of improvements made in patterns, design, or what has been called advancement in the art.

C. J. H. **Woodbury** said that the distribution of power by various types of porches following the open belt porch, was an important feature in depreciation of mill property. Porches enclosed by wood sheathing, followed by the type at the side of the building and others, in all of which power was distributed along the lines of belting, and finally the belt porch projecting into the mill by which the power was distributed along the lines of shafting, were an indirect source of depreciation. In new mills these forms of construction had been displaced by the electrical transmission of power, which did not require more than a provision for the conductors. The old mill buildings were depreciated by this subsequent electrical invention because these belt porches formed a portion of the structure and for reasons of strength could not be removed.

Thus the advent of the electrical transmission of power with its freedom from requiring structural provision in a mill hitherto necessary, had within a few years enabled engineers to design a mill solely as a manufacturing structure without making arrangements for belt porches, without their attendant expensive impediments to floor space and light, and this improvement has in like manner depreciated mills of earlier types of construction, independent of wear and tear.

There was a depreciation from the contingency of an abandonment of the site of the mill, especially as the result of a fire. In such a case the owners of a mill at a water power distant from a railroad might find it more advantageous to connect the power house to an electrical generating plant and carry the wires to another site along the line of a railroad, than to rebuild on the old site.

A saving in gas of $3000, or 6 per cent, on the cost of a mill, was revealed in the case of removal of the machinery to a new building having larger windows. In both instances the buildings were lighted by the town gas at the same rate and the identical meter was used. It would not generally be assumed that modern windows would depreciate a mill having old types of windows 6 per cent.

He said another form of the distribution of depreciation was that of insurance. He knew of one cotton mill which had been insured for a number of years, under the factory mutual insurance plan on the basis of paying gross premiums subject to returned dividends, which instead of being credited to the insurance account, were invested in the stock of the mill purchased on the open market and in a few years a permanent insurance fund thereby secured, the income of which in the shape of dividends was sufficient to pay for the insurance without annual expenditures from the merchandizing income of the mill.

Charles T. Plunkett asked if the author's statements "depreciation is the falling off in value," and "depreciation begins at once, however small," must be taken in with a series of years in order to make up the depreciation. He was answered in the affirmative.

From the author's statement regarding the making up of the valuations of a plant, "an investigation must be made into the working of the plant, comparing it with other plants in competition with it," Mr. Plunkett wanted to know if the valuations were comparative. The author said he regarded commercial valuations as comparative.

The Author. The discussion of the subject has turned upon the matter of depreciation which is quite a difficult problem. It seems that instead of closing the subject with this paper and its discussion an effort should be made on the part of the Society to take up the subject of depreciation and maintenance to determine if possible what may be the best methods to pursue in various industries and so leave the question open for further enlightenment.

MEASUREMENT OF NATURAL GAS

By Thos. R. Weymouth, Published in The Journal for November 1912

ABSTRACT OF PAPER

In the measurement of natural gas there are two distinct requirements to be met. The first relates to the determination of the open flow capacity of gas wells, for which two principal methods are used, namely, the "minute pressure" measurement and the pitot tube. This paper describes these methods, giving the proper formulae to be used with them.

The second requirement is that of the measurement of flow in closed pipes. While large proportional meters are used extensively for this purpose, the high pressures often encountered have a tendency to introduce serious errors, making it necessary to resort to more accurate devices. Of these, the best known are described, namely, the Thomas electric meter, the venturi meter, the pitot tube, and the orifice. The general formulae are given for the last three named, together with their derivations.

DISCUSSION

C. J. Bacon. The principal objection Mr. Weymouth has to the venturi meter is its complicated formula. In view of the amount of preliminary experimental work necessary to establish the coefficient of the pitot tube independently for each condition of velocity, pipe diameter and roughness of interior surface, under which it is to be used, it seems to me that the venturi meter is by far the more generally applicable, since no preliminary work of the above nature is necessary. The coefficient for gas has been determined by various investigators for tubes from 2 in. to 4 and 5 ft. in diameter and has been found to be 98 per cent for the large sizes at the most practicable velocities. By plotting to a wide scale that portion of the formula involving the ratios of areas, pressures and specific heats, the computation of results becomes at least as simple as for the pitot tube. In the usual applications a variation of one per cent in the ratio of specific heat introduces an error of only 0.02 of 1 per cent. In

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my work a ratio of areas of one to nine is generally maintained. The loss of line pressure through venturi gas meters having this ratio of areas has been shown to be 1/9 the differential pressure, therefore not of great importance. The various types of recording instruments on the market make possible continuous records of all data except density. I have had in use for a year or more some combined indicating and recording instruments graduated to show the actual volume of gas passing per minute. One of them is connected to a 54-in. diameter venturi meter located 600 ft. away, and in spite of the distance for transmission of a slight pressure difference it has been found very sensitive and accurate, moreover requiring almost no attention.

C. C. THOMAS said that of course it required electric energy to operate the electric gas meter, about 1 or 1½ cents worth per 100,000 cu. ft. of gas measured. It required about 1 kw-hr. per 100,000 cu. ft. of gas. The necessity of increasing the velocity of gas in order to measure it by means of pitot tubes also required energy. In order to produce a readable height of water column (it should not be less than 4 in.) the velocity of gas was increased at the pitot tubes by an amount requiring about 1 per cent more energy to be expended in the pumps than was required with the electric meter installation. This was the case also when the measurement was made by means of orifices, as it was necessary to produce a fall of pressure of about 1 lb. per sq. in. from one side to the other of the orifice. This reduced the suction pressure on the pumps.

Deposit on pitot tubes had a serious effect on accuracy though it was possible to avoid this to some extent by using screws. The pitot tubes were standardized in place, but it was very difficult to check them afterwards. An electric meter could be checked for accuracy at any time simply by throwing in a switch and noting whether or not the system came to a balance. No computation of results or reference to charts was required and no straight length of approach was necessary.

E. A. HITCHCOCK[1] (written). In 1908 with Mr. Eugene Coste of Toronto I had occasion to standardize with natural gas a set of three pitot tubes, 2, 3 and 4 in. similar to those described by Mr. Weymouth in Par. 27. A total of 34 runs were made under a variety of velocities and pressures, the quantity of gas flowing being determined by means of a gas holder having a capacity per foot of rise of 5246.5 cu. ft.

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[1] Prof. Exper. Engrg., Ohio State Univ., Columbus, Ohio.

In order to reduce to a minimum the effect of temperature on the gas holder all the experimental work was carried on during the night and to obtain parallel flow there was laid a straight run of pipe for 92 ft. leading to the brass pitot tubes.

For gas having a flowing temperature of 40 deg. fahr. with a storage temperature of 50 deg. fahr. and a pressure of 14.7 lb. the constants K were found to be 1511 for the 2-in. tube, 3384 for the 3-in. tube and 5734 for the 4-in. tube where

$$Q. \text{ (cu. ft. per hr.)} = K\sqrt{\frac{h\,P500}{T}} \quad (.668 = \text{sp. gr. gas})$$

The actual diameters of the tubes calibrated were 2.08 in., 3.07 in. and 3.98 in. respectively. It was found, as stated by Mr. Weymouth, that for each tube throughout a wide range of velocity head readings, the coefficient was almost constant.

Taking the constants as given above, solving for Q for any condition, making the proper substitution in Equation [7] and solving for E, I find that E is not constant for the different tubes but decreases with the diameter of the tube:

Actual diameter of tube d, in.	Efficiency E
2.08	0.843
3.07	0.866
3.98	0.874

This is explained in that no correction is made for the area taken up by the dynamic tip in the brass tube. For the above cases this tip had an outside diameter of ½ in. and therefore E will decrease until the actual diameter of the pipe is ½ in. when E would become zero because Q would be zero in that the tube would be plugged with the dynamic tip. For this reason it would seem that d should be taken in actual equivalent diameter.

Mr. Weymouth states that it is not advisable to use the pitot tube for flows giving a differential pressure of less than 2 in. water. Judging by my experience with the type of apparatus he has described, I can readily see why this may be advisable. The reading scale is graduated in 1-10 in. and the average observer will read to the nearest 1-10 in.; therefore with a 2 in. head of water, there might be an error with one reading of 2.2 per cent. Also there seems to be considerable vibration to the water meniscus so that it is difficult to read to less than 1-10 in.

To accept a 2-in. minimum would as a general rule eliminate the use of the pitot tube for measuring natural gas in a great many cases, for of the many hundreds of readings I have taken during the past 13 years, in the natural gas field on lines from wells to mains and mains to stations the velocities which gave 2 in. or more of water were the exception.

The form of instrument used was a traversing dynamic tube made of 1.4-in. brass pipe, a stationary static tube of the same size and material and the form of manometer brought out by Prof. S. W. Robinson. With this form of apparatus and using alcohol in the manometer there is no difficulty in reading to 1-100 in. which, with a velocity head of only ½ in. and an error in reading of 1-100 in., would mean an error in the quantity of gas flowing of only 1.4 per cent and this probable error is reduced by taking many independent readings.

The greatest advantage of the pitot tube in the measurement of natural gas is its great simplicity and ease of application. Several determinations can be made during the same day on different lines in the same field in that it should not take more than one hour to connect the instrument to the line after the gas pressure has been reduced to 20 lb. or less.

The Author. In referring to the preliminary work necessary to establish the coefficient of the pitot tube Mr. Bacon doubtless had in mind the form of tube intended to be used within an ordinary pipe. In this form the pitot tube is more of a portable instrument than one adapted for permanent installation, and should not be compared to the venturi meter. For such comparison the form of tube described in Par. 22 must be chosen, inasmuch as its field of usefulness is the same as that of the venturi meter. The total amount of preliminary work necessary with this type of tube is merely its calibration against a standard tube or other accurate measuring device and involves from one to four hours' time, which seems to the author to be about as little as one could expect to be spent upon any instrument of the importance of those considered. Much labor and painstaking care were applied to the derivation of the coefficients of the standard tubes mentioned in Par. 23, but these coefficients having once been determined, it is a simple process to ascertain from them the coefficients of the other tubes calibrated against them. The standard tubes are preserved in a testing station used solely for the calibration of other tubes and are in service only during the progress of such calibration work.

The computation of the quantity of gas passing through pitot tubes in commercial use is extremely simple. From a book of tabulated values of $\sqrt{h\,(p + 14.4)}$ corresponding to all values of h from 0 to 28 in. of water, by tenths, and of p from 0 to 500 lb. gage, by pounds, the value of $\sqrt{h\,(p + 14.4)}$ corresponding to observed readings of h and p is read off and written on a form every 15 minutes. At the end of the day these "extensions" or values of $\sqrt{hP}$ are added and the sum multiplied by the quarter-hour coefficient of the tube used, giving the total quantity of gas passed. The method of computation of venturi meter observations as outlined by Mr. Bacon does simplify the use of the formula of Par. 12, but can hardly be said to be as simple as the pitot tube computation, as it would require first, the computation of $\frac{P_2}{P_1}$ from the observations of P_1 and $P_1 - P_2$. Then the corresponding value of the radical must be obtained from the chart. This value must then be multiplied by the value of P_1 and also by a constant, depending upon the particular venturi instrument used and the remaining factors in the formula. This computation could all be reduced to much simpler form, however, if tables were computed giving the values of $\frac{Q}{A_2}$ for all possible combinations of P_1 and P_2. Such tables would then be applicable to all venturi meters with the same ratio of entrance area to throat area.

The cost of measuring gas by pitot tube as influenced by the drop in pressure can be made small by properly designing the station. In the case assumed by Professor Thomas, the pressure drop of 28 in. or about 1 lb. would be equivalent to 1.2 hp-hr. per 100,000 cu. ft. per hr., assuming the gas to be pumped from 80 to 350 lb. gage pressure. By using a 6-in. tube instead of a 5-in., the drop in pressure would be reduced about 50 per cent, measuring the same quantity of gas, and the cost would thus be cut in half.

It is true that if pitot tubes should be filled with deposit their coefficients, which vary as d^2, would be seriously affected. As a matter of fact, however, such deposits do not form, due to the high velocity of the gas in the polished tube. Sometimes the tips will become clogged with dirt, but this instantly becomes apparent on the gages and the tips can then be "blown out" or removed from the tubes and cleaned.

All pitot tube stations should be installed with provision for inserting a portable standard tube for calibrating the permanent tubes. It is then a simple matter to standardize all the tubes in a station as frequently as is necessary.

The coefficients of the tubes referred to in Par. 28 were determined in the same manner as those described by Professor Hitchcock and the author is unable to understand the variation in the values of E as shown by him. Even though the tip were assumed to be so large as to fill the pipe it would not mean that E would fall to zero, for while Q would then be zero, h would also be zero, and E could remain constant.

The limits mentioned in Par. 33 apply only to installations of the type described, and are a result of the simple form of U-gage scale usually used with such permanent stations. When a properly designed scale is used for the accurate reading of small differential pressures, the range of the pitot tube is increased to give accurate measurements over extremely wide limits, for the fundamental principle of the tube itself holds good irrespective of the velocity, and the question resolves itself into one of the accurate measurement of small differences in pressure. This is especially true in portable tubes or tips. The author makes use of such a form in field work, especially in the measurement of the capacity of wells feeding into main lines, and obtains very accurate results with small differentials by using an inclined U-gage.

Where trouble is experienced from vibration of the water meniscus, it can be overcome by inserting in each of the pressure lines a diaphragm with a hole in it about 1/32 in. in diameter. If the installation is permanent the same object may be attained by inserting in each of the pressure lines a joint of 6-in. pipe, capped on both ends, for acting as a reservoir or cushion to dampen the vibrations and give a true average of the pressures.

MEASUREMENT OF AIR IN FAN WORK

By Charles H. Treat, Published in The Journal for September 1912

ABSTRACT OF PAPER

The paper discusses the use of the pitot tube for fan testing with particular emphasis on the correct kind of tube to be used. It describes a simple and accurate method of calibration of impact and static orifices, and the instruments to be used in fan testing, as well as the general method and arrangement of the tests. It shows further the derivation of the formula for friction in test pipe, and the method of correcting test results to standard weight air. The paper further contains proofs that the volume discharged from a fan is the same at all densities, other conditions being the same, and indicates the formulae and calculations used in the test, such as the formula for the determination of air horsepower on the discharge and suction side, efficiency of a fan and its speed. Finally, the question of the average velocity of flow in a pipe is discussed.

DISCUSSION

W. H. Carrier stated that the same kind of pitot tube as that used by Mr. Treat had been used for a long time at the works of the Buffalo Forge Company, however, instead of using two tubes side by side, connecting to the static member and to the total pressure member, one tube is placed inside of the other, so that the pitot tube can be more easily inserted in the pipe. In this construction there is only one pipe to be handled, and it requires only about one-half as long to construct as Mr. Treat's.

There is one point worthy of particular attention as the feature probably responsible for a very large amount of inaccuracies in fan tests and misleading statements as to efficiencies, such as claims of efficiencies of 83 per cent or even as high as 90 per cent, which cannot be attained in ordinary fans for low-pressure work. The actual efficiency of those of the very best design working under the best conditions is 70 to 75 per cent, while fans of the multivane types of ordinary commercial design have efficiencies

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

varying from 45 to 60 per cent only. The reason why unusual efficiencies are shown in some tests is in all probability because of a slight leak in the static member, which usually happens unless precautions are taken. This leak reduces the static pressure and a further reduction may be produced by some of the minute openings being clogged by dirt. Even a small reduction, say 5 per cent, will produce an apparent error in the reading of the velocity pressure of about 15 per cent, which will result in the amount of air calculated as delivered being 7 or 8 per cent larger than is actually the case. The error due to these causes may often be as large as 20 to 30 per cent. The proper method is to test the connections to both the static and total members as to tightness by blowing into the connecting tube, depressing the water column, and then holding it, with the thumb over the opening, to see if any drop occurs in the water column.

Sanford A. Moss. Experience with velocities of the order of magnitude of those used by Mr. Treat as well as very much higher velocities has shown that Mr. Treat is correct when he states that for any ordinary change in an impact tube no inaccuracy results but that a static orifice which reads correctly is not easily obtained. I have had most successful results in measurement of static pressure by means of a hole in the pipe wall, succeeded by some length of straight pipe and preceded by a considerable length of straight pipe. With the static pressure obtained in such a way the pitot tube becomes merely an impact tube.

Some years ago I used an arrangement such as is shown in Mr. Treat's Fig. 3 with a jet discharging into the atmosphere. Mr. Treat, however, seems to use a jet discharging from a long straight pipe of constant diameter. In such a case the velocities at the point of discharge are variable and gradually decrease from the maximum value at the center to a small value close to the edge. As is well known, the curve giving these velocities for various diameters is an ellipse. I used an orifice consisting of a gradually rounded approach succeeded by a parallel portion about one diameter in length and preceded by a long straight pipe with a diameter about three times that of the parallel portion at the discharge of the orifice. It can be shown that such an orifice gives a jet with practically uniform velocity and that the pressure in the jet must be atmospheric.

I inserted a pitot tube similar to that used by Mr. Treat in such a high velocity jet and found that for high velocities static pressure was very slightly less than atmospheric. For a velocity of about 400 ft. per sec. the static pressure was 0.6 in. of water below atmosphere. For velocity up to about 80 ft. per sec. the static pressure was practically atmospheric. Other forms of pitot tube in such a jet showed static readings with much greater errors.

Mr. Treat's suggestion regarding an inclined gasolene tube for pressures of less than 1 in. of water is very interesting. I would like to inquire how he secures an exact value of the zero angle, how he secures the density of the gasolene and how he avoids change of density by evaporation of the more volatile part of the gasolene from time to time.

The variation of pressure with square of velocity and power with cube of velocity for a fan discharging against constant resistances mentioned by Mr. Treat was considered theoretically by Professor Rateau many years ago and is undoubtedly a very exact relation so long as the pressures are so low that the change of density is not appreciable.

All of Mr. Treat's methods seem very carefully and accurately laid out and it is pleasant to know that the measurement of quantity in his fan blower work is being carried out with precision.

J. H. Browne said he would like to see some method developed by which the pitot tube could be used when the fan is used to produce either forced draft under a boiler or induced draft over a boiler. This would show the exact conditions of operation better than the ordinary water tube or inclined gage because in the latter case the thickness of the fire affects the results.

C. G. de Laval (written). On using a pitot tube for measurement of air one must not overlook the question of moisture in the air as this affects the air density; also, when water is present there will be a wide variation in the velocity, so that to be fully accurate relative humidity should be taken into account. In the usual cases the velocity is not constant in the cross-section and particular care has to be exercised to read the pitot tube carefully; wrong records may be due to fluctuations, and coefficients of corrections have to be used in order to get the correct measurement. The paper aims to show a tube that would give accurate results in a simple way; the best and most reliable is one that will combine the impact and static in one, and in such a way that the dynamic and aspiration effects neutralize each other so that the real pressure is obtained.

For measuring air velocity by the formula $v = \sqrt{2gh}$, the density of air and its velocity head, temperature, atmospheric pressure and moisture must be taken into account.

The density

$$D = \frac{0.0807\,(p - 0.379\,hv)}{(1 + zt)29.921}$$

where

0.0807 = weight of 1 cu. ft. dry air at 32 deg. fahr. and atmosphereric pressure of 29.921 in.

p = atmospheric pressure

h = relative humidity

v = vapor pressure

$1 + zt$ = ratio of volumes of dry air at 32 deg. fahr. and at $(32 + t)$ deg. fahr.

t = temperature of dry air above 32 deg. fahr.

0.379 = per cent of vapor in 1 lb. saturated air at 32 deg.

It is believed that a single tube at center will correctly register the velocity with a correction of 4 to 5 per cent for the average over the entire pipe or outlet and that it will be necessary to correct further for moisture in the air; it will be also found that the velocity of the air materially affects the correctness of readings by pitot tubes. For low velocities, say below 5000 ft. per min., a special form of gages will have to be used in order to be reliable and to register accurately the velocity heads, while for higher velocities the instruments of the pitot tubes are fairly reliable as to readings.

The electric meter is probably the most accurate, it measures the energy necessary to cause change in temperature, and this is proportional to the weight of air flowing.

$$Q = \frac{E}{t \times s}$$

E = energy to raise temperature

Q = weight of air through t deg.

s = specific heat of unit of weight at constant pressure.

The electric meter is independent of variation in velocity of the air at the different parts of pipe. Measurements used are all electric and can be read to close observation and are not affected as in the pitot tube and venturi meter by eddies and pulsations. It is to be noted that neither pitot nor venturi meters will or can lend themselves to continuous graphical results due to the small power available for recording, while the electric meter of Professor Thomas can give a continuous reading through an ordinary wattmeter, and which is still better, the readings can all be obtained without any calculation, as it necessitates only the electrical energy transformed into standard cubic feet, and its accuracy depends only on its ability of measuring electrical energy.

In closing, Prof. C. C. Thomas stated, in reply to a question from Mr. Moss, that in regard to the use of light fluids such as gasolene for maintaining the difference between the static and velocity pressures, there was some difficulty at times due to the varying vapor pressures in the gages. Almost all such gages are closed at one end, and there is a different pressure above the fluid for each temperature, so that in summer it is difficult to get the same results as in winter.

The range of the pitot tube stations is determined by the smallest and the greatest heights of water columns which it is found practicable to read accurately, and to obtain. About 4 in. is the lower limit and 28 in. the higher. This gives the tube a measuring range of the square root of 7 or about as 1 is to 2½.

The author's closure is to be published later.—Editor.

AIR IN SURFACE CONDENSATION

By Geo. A. Orrok, Published in The Journal for November 1912

ABSTRACT OF PAPER

This paper is an addition to the author's paper on the Transmission of Heat in Surface Condensation and gives the results of his investigations on the amount of air present in feedwater and the presence and effect of air in surface condensers, and describes an apparatus for measuring the air leakage.

DISCUSSION

H. A. Everett.[1] Air has such a serious retarding effect upon condensation that any work which permits of a closer analysis of its effect is of prime importance in condenser design, and we are greatly indebted to Mr. Orrok for his work in this direction.

In 1908 D. B. Morison[2] as the result of experimental observation, said that "when the entire feedwater passes through an air pump the air in the pump discharge amounts to from 1½ to 2½ per cent by volume of the water, and that fresh water carried in tanks for use as auxiliary feed contains from 2 to 3½ per cent of air by volume." These are in accordance with the values given by Mr. Orrok and are interesting as confirmatory data.

With reference to air entering by leakage there have been to date no quantitative experiments published, and those given by Mr. Orrok are of tremendous value. From them it appears doubtful if, in any case of normal leakage, the air present would be sufficient to affect appreciably the temperature of the steam at *entrance* to the condenser, though of course during the passage *through* the condenser the air richness is in ever increasing proportion as the steam is condensed out, and its effect upon condensation becomes of vital importance. The deterrent action of

[1] Assist. Prof. Naval Architecture, Mass. Inst. Tech., Boston.

[2] Trans. Inst. Naval Architects, vol. 50, p. 150

Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

air on heat transference is apparently a dual one, (*a*), the insulating effect upon the tubes and (*b*), the reduction in the temperature of the steam by the reduction of the partial pressure due to the steam as the steam is condensed out and the air richness increases.

From the experiments by J. E. Smith[1] Mr. Orrok concluded in 1910 that the heat transference is proportional to the ratio of the partial pressure of the steam to the total pressure raised to the fifth power $\left(\frac{P_s}{P_t}\right)^5$ and now suggests the second power as being desirable. It should be borne in mind that the experiments of Mr. Smith were made in a condenser with no air pump, and therefore the flow of steam by the tubes was very slight. This would have the effect of permitting the zone of air around each tube to be much larger than in actual condensers where the velocity of the steam by the tubes is great, and therefore its effect would be correspondingly greater, for air is a good thermal insulator.

While this would account for the rejection of the fifth power, is Mr. Orrok warranted in suggesting two as the exponent for the ratio $\frac{P_s}{P_t}$? As from his plot of Fig. 6 the exponent is evidently considerably nearer unity than two and it is much to be desired that a description be given of the manner in which the data for the curves of Fig. 6 were taken, as knowledge of this would be of great assistance in determining the reliance to be placed upon a factor of such prime importance in his equation.

Past experience in the determination of temperatures inside of condensers during operation has been most unsatisfactory, and data of this sort will be very welcome to those engaged in condenser design. In view of the apparent unreliableness of the factor $\frac{P_s}{P_t}$ for determining the effect of air, would it not be desirable to drop the term from the original equation and to obtain the reduction in heat transference due to air leakage in another way? If temperatures might be predicted at different intervals down the tubing, it would be comparatively easy to estimate the actual heat value of surfaces located at these points from which a total or mean value could readily be derived.

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[1] Victorian Institution of Engineers, December, 1905

A. G. Christie. Mr. Orrok is to be congratulated for his initiative in undertaking such a complete series of tests the results of which, as embodied in his paper, give data and information of great value to designing and operating engineers of power plants using surface condensers. His discussion not only throws new light on some vaguely understood conditions, but also offers a solution to many questions in plant operation which have puzzled engineers. The simplicity and reliability of the methods and apparatus employed by Mr. Orrok deserve commendation. The tests have proved the effectiveness and usefulness of open heaters as air removers from boiler feedwater. This decrease in air carried to boilers not only improves the vacuum but also reduces boiler corrosion.

It is stated that most of the air comes into the condensing system through leakage in the cast-iron shells, gaskets and expansion joints. A number of years ago it was noted in a barometric condenser installation that air leakage was apparently taking place under high vacuum through the cast-iron pipes themselves as the vacuum could be improved by painting the pipes with asphaltum. The piping was well made and apparently free from blow-holes. The theory was advanced that cast iron was more or less porous to air when subjected to high vacuum. In order to test this theory some cast-iron exhaust pipes of good quality were secured from a leading condenser manufacturer and tests conducted under the writer's direction at the University of Wisconsin. It was first attempted to measure the air leakage by a method similar to Mr. Orrok's, but this was not found sensitive enough under the circumstances. Comparative results were obtained by producing a high vacuum in the piping by means of a Hubbard pump, closing off all connections and noting the rate of decrease of vacuum. Knowing the volume of the pipes, the rate of air leakage could be computed.

It was also decided to test the effectiveness of several commercial paints or coatings for vacuum work and to note their performance under heat. A study of the results of these tests led to the following conclusions: The actual leakage of air into the pipes was very small and would not amount to any significant quantity as compared with the other volumes of air that entered through other sources. It is quite probable that practically all this leakage was through the valves, pipe connections and gaskets under the end heads. The rate of leakage was practically constant whether the pipes were bare or painted. It might therefore be said that good cast-iron pipe with a coat of suitable paint is proof against any considerable leakage of air.

Considerable trouble was experienced in preventing air leaks through the gaskets under the end heads, especially after the pipe had been heated up. Hence the bolts and gaskets at the joints should receive particular attention when air leaks are suspected. The use of cloth inserted gaskets should be avoided.

The tests were not conclusive with regard to the effectiveness of the different paints in reducing vacuum losses. Paints with asphaltum base were very effective in preventing leaks at low temperatures, but softened and tended to drip at temperatures from 210 deg. to 225 deg. fahr., which would occur should the vacuum fail. One paint, said to be a linseed oil preparation with a peroxide of iron base, formed a close impervious film on the piping and showed no deterioration from the temperature changes within the range of the tests.

It would therefore seem that if the cast-iron portions of the condensing equipment were covered with a suitable paint, the only remaining sources of trouble from air leakage would be the bolts and gaskets at the joints.

Referring to Par. 28, the writer has frequently been puzzled to account for inconsistencies in vacuum temperatures and will welcome any new information on this subject. In one test several calibrated thermometers were tried in a well in a certain part of a jet condenser apparently well out of the path of the steam, yet each showed a higher temperature than that corresponding to the vacuum shown by an adjacent mercury column. On another test the exact opposite occurred as the temperatures observed were much too low to be accounted for by partial pressures of the air present.

In regard to the drop in vacuum through condensers, it is of interest to note European practice in condenser construction. Some British manufacturers maintain that for high efficiency of the condenser, the steam path must be so designed as to obtain high velocity through all the tubes with small loss of head. This requires a straight path through the condenser with no baffle plates and also requires a condenser with decreasing cross-section from the steam inlet. Such construction avoids dead corners for the collection of air, and at the same time, the condensed steam is swept off the tubes as fast as it forms by the high velocity.

Many continental manufacturers have adopted the practice of leaving open channels through the nests of tubes to provide ready access of the steam to all cooling surfaces. As a rule baffle plates are also employed to direct the condensation to the side of the shell instead of allowing it to drip over the tubes below.

The theory advanced by several writers that seems to account in the best manner for the fall in vacuum with increased quantities of air is as follows: As steam condenses on the tube surfaces, the air is left behind and the medium surrounding the tube then contains proportionately much greater quantities of air than the steam entering the condenser. The pressure of this air lowers the partial pressure of the steam and consequently its temperature. Hence there is a less temperature difference between the tubes and the steam and therefore the rate of condensation is lowered. This theory emphasizes the necessity of providing in the design for a rapid sweeping away of the air to the air pump as the steam condenses. The high velocities maintained in some British condensers assist materially in securing this result.

William Weir.[1] As the writer's experience is chiefly associated with marine practice it differs from Mr. Orrok's on many points, but the differences may be of interest particularly as the limitations of weight and space on board ship entail the utmost care in the design of a condensing installation.

The question of air to be handled by the air pump naturally divides itself into two considerations, the amount of air entering the system through the medium of the feedwater and the amount of air entering the system as direct leakage. Apart from thermal considerations, the Weir direct-contact feedheater was introduced to prevent boiler corrosion due principally to the air and other gases contained in the feedwater. This type of heater is situated on the suction side of the feed pumps, subjecting the feedwater to a reduction of pressure and an increase of temperature, which results in the water boiling and giving off the air and gas practically in their entirety. In the absence of such apparatus the feedwater will enter the boiler containing air in proportion to the feed temperature at the feed pump suction.

As regards the amount of air in feedwater at different temperatures, the writer cannot agree with J. A. Smith's curve of emissivity of gases as in his experiments emissivity was almost entirely controlled by convection due to the stagnant condition of the experimental medium. Feedwater in any feed system is practically never still, and the actual curve of emissivity is of a totally different nature to that shown by Mr. Smith, and broadly speaking shows greater emissivity at the commencement of the heating range than at the later stages.

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[1] G. & J. Weir, Ltd., Cathcart, Glasgow, N. B.

In turbine installations other controlling factors generally prevent the adoption of direct-contact feedwater heaters, and accordingly the feed heating is generally done on the pressure side, which does not affect to any great extent the amount of air entering with the feedwater. In such installations a large proportion of the total air enters with the feedwater. It is astonishing, however, to note that Mr. Orrok considers 15 to 20 cu. ft. of free air per minute a reasonable total air leakage on say a 12,000 kw. installation. This seems abnormally high, and quite incompatible with good workmanship, or if associated with turbine packing glands, with good design.

The first essential in any plant designed for high vacuum is to take every possible measure to keep the air out, and the actual air leakage into such a system may be reduced in every case to a comparatively trivial amount. In marine work the condenser shells are of steel plate, and in every case the entire low-pressure system is carefully water tested after erection and before starting up, and even in land installations wherein the condensers are sometimes of cast iron, it is not difficult to maintain practically complete air-tightness particularly in a land installation where the eduction pipe inlet to the condenser is water sealed, and wherein the only other pipe connections are on a simple line of air pump suction pipes. It will be obvious that in a marine installation the difficulty is much greater owing to the extensive and complicated pipe system under the vacuum.

Mr. Orrok's experience differs also as regards air leakage at light loads, as light loads are always associated with less air leakage. It may be of interest to give an actual example of this phenomenon. Take a torpedo boat destroyer of 20,000 s.h.p. On this vessel there are two main condensers of 6000 sq. ft. each, i.e. the total cooling surface is 12,000 sq. ft; there are two main air pumps of the Weir dual type each comprising two barrels 22 in. in diameter by 15 in. stroke. At full power with a sea temperature of 55 deg. the vacuum is 28.2 in. with both air pumps running at 50 double strokes per minute. At cruising power say 2000 s.h.p., with one air pump running at 30 double strokes on both condensers the vacuum is 28.9 in., in other words, the air to be handled by the air pump in a tight system is largely controlled by the actual amount of feedwater, and correspondingly the air brought over with it.

In connection with this example it may be of interest for American central station engineers to consider the relative proportions as regards cooling surface of these "uniflux" condensers as compared with the land practice obtaining in their country.

With regard to Mr. Orrok's remarks on the loss of pressure between the exhaust pipe and condenser base, it does not seem to be a matter of shallow condensers as compared with deep condensers, but rather the adherence to the correct principles of design as regards permissible steam velocities, contour of shell, and pitch of tubes, which governs the question.

With reference to the effect of air on the actual heat transmission in surface condensers, it is apparent that this effect is different on practically every row of tubes in a surface condenser, and accordingly such experiments as J. A. Smith's are of little practical value as the element of steam flow or velocity was entirely absent.

Mr. Orrok's paper tends to confirm the writer's experience with dry air pumps of the type he has dealt with, and it has always been a matter of wonder that such types should have been adopted on any scale. All such pumps are greatly handicapped as compared with the ordinary three-valve air pump fitted with cold injection supply, and in this connection it may be of interest to refer to a paper read recently by the writer before the Institution of Engineers and Shipbuilders in Scotland, wherein are given a number of particulars concerning marine practice in surface condensing installations.

J. J. Brown. In connection with the author's figures as to the amount of air entering through the prime mover, the following data, showing the amount of air entering through turbine seals, may be of interest. They were obtained by the Wheeler Condenser & Engineering Company with their portable testing gasometer, similar in design to Mr. Orrok's, and may serve to emphasize the importance of maintaining proper pressure on the steam seals.

In the test in question, which was made on a jet condenser serving a 2000-kw. turbine, at no load and with no steam on the turbine seals a total of 86 cu. ft. of free air per minute entered the condenser, a corrected vacuum of 26.6 in. being maintained under this condition. With a normal amount of steam on the seals, and a mercury manometer registering a slight pressure, 64 cu. ft. per min. entered the condenser at no load, and the vacuum was raised to 28.5 in. On a similar unit of like size, approximately the same figures were obtained, as follows: with a load of 1650 kw. on the turbine, and no steam on the seals, 91 cu. ft. of free air per minute entered the condenser, the vacuum dropping to 25.9 in., corrected. With normal steam pressure on the seals, the amount of air was reduced to 56 cu. ft. and the vacuum increased to 28.1 in. A further increase of pressure on the seals had no appreciable effect.

It is interesting to note that the abnormal quantity of air discovered by these tests enabled the detection of leaks. Upon remedying them, the condensing plant operated well above the guarantee.

Mr. Orrok's chemical determination of the amount of air in feedwater suggests some rather unusual figures recently obtained while testing a unit. As is known, the normal quantity of oxygen in free air amounts to about 20.7 per cent. Analysis of the air extracted from a condenser revealed the fact that this amount of oxygen had been increased to an even 25 per cent, the relative quantities of CO and CO_2 remaining the same. These figures correspond to the 20 to 30 per cent of oxygen obtained by J. A. Smith,[1] in analyzing the non-condensible vapors from a condenser.

In Fig. 3 are given curves showing the relation between load and the drop in vacuum through the condenser. Were these tests made at approximately the same vacuum, and did this vacuum remain practically constant throughout the range of load represented by each of the curves? It is well known that decreasing the pressure increases the volume; in accordance with the laws for flow of gases through orifices, by which the loss of pressure is stated as varying as the square of the velocity and inversely as the density, a loss of pressure twice as great would be expected if the velocity were doubled by doubling the volume, with the weight of steam remaining constant.

In connection with this subject of drop in pressure through condensers, experience has shown that a proper arrangement of tube surface will reduce this loss to a fraction of an inch. The most important consideration is that the incoming steam meet the maximum initial exposure of tube surface, and rectangular shells have been developed with this point in view. This is probably the nearest commercial approach to the wide shallow condensers which Mr. Orrok states should give the best results and with them during the winter season vacuums of 29.3 to 29.5 at 30 in. barometer have been maintained. The drop in pressure at the enormous volumes reached with these vacuums would be considerably larger than at 28 in., so it is evident that the loss is not excessive.

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[1] London Engineering, Oct. 7, 1904

Another point to be remembered is that the volume of air increases tremendously at high vacuums. The addition of air to the total volume hence operates to cause a greater drop in pressure. While the presence of air in a condenser is detrimental under any condition, its effect is most clearly demonstrated at these high vacuums.

From the standpoint of the condenser manufacturer, it is of great value to have such a paper as Mr. Orrok's brought to the attention of engineers, and it is to be hoped that the time will come when every power station will be equipped with a gasometer or a similar device for testing for air leaks. As it is now, the condenser manufacturer must design his air pumps to handle not only the air which he knows by experience will enter with the steam or by infiltration; in addition, he must assume the responsibility for turbine seals, for careless pipe joints, and for slipshod maintenance. That is, he must proportion his air pumps to handle far more air than should be necessary, and the net result is a considerable over-all loss. It is no exaggeration to say probably over 75 per cent of the vacuum troubles in condensers today may be traced directly to an abnormal air leakage. It is to be hoped that further investigations similar to Mr. Orrok's will be made, in an attempt to determine the air displacement necessary, say per 1000 lb. of steam under standard conditions. The company with which the writer is connected has been working on this subject for the past two years, but if such a figure could be obtained by independent investigators it would define sharply the responsibility of the condenser manufacturer, and it would result in more careful attendance of plant and in higher efficiency, for, as Mr. Orrok points out, "the work necessary to maintain tight condensers more than pays for itself."

G. J. FORAN. The entire membership of the Society is indebted to Mr. Orrok for the data presented upon the amount and variation of air leaks found in large operating units and the effect upon the results obtained.

As I understand it, Mr. Orrok presented the paper without comment on much of the data, with the idea of creating an interest and starting discussion upon the various lines. The brevity of the presentation and the absence of any discussion or demonstration of the data has already caused some misunderstanding and certain discussions which Mr. Orrok would probably not endorse.

The entire field of the effect of air upon surface or jet condensation has been the subject of special study by me for many years, but I shall confine myself only to features of unusual interest or the discussion of such data as might lead to erroneous deductions.

Referring first to the percentage of air by volume at various temperatures, as given in Par. 6, the variation in percentage corresponds quite closely to my own observations and study, and in ratio of variation, although not in exact quantity, to Winkler's tables as presented in Castell-Evan's Physico-Chemical Tables, edition 1911. Two tables are given showing the absorption of air by water at different temperatures; the first table assuming that the pressure of the *air* outside of the liquid is constant at 760 millimeters, the second table assuming that the total pressure outside of the liquid remains constant at 760 millimeters, the pressure due to the air being the difference between the total pressure (760 millimeters) and the pressure of the aqueous vapor due to the temperature. The tables were calculated from the absorption power of water for oxygen and nitrogen in the necessary ratio for the formation of air; the volume of air so stated is always stated in *dry* air, not saturated, a fact not definitely stated and usually overlooked.

Heretofore it has been customary in condenser work to base all calculations for the air contained in the water upon the ratio of total pressures and temperatures. It is apparent that this should be modified upon the basis of the second table referred to, and that the quantity of air present, outside of temperature considerations depends solely upon that proportion of the outside pressure due to the *air* alone.

It is well known that if a given space is saturated with aqueous vapor at a given temperature, the corresponding pressure and weight of aqueous vapor is definitely known and may be found in saturated steam tables, and this pressure and weight is absolutely independent of the presence of air or other gases. These other gases will influence the total pressure in the space, and they themselves will have a pressure and weight proportional to their portion of the total pressure; but the pressure and weight of the aqueous vapor remains the same as if there were no other gases present.

In Fig. 7 are curves, *A* and *B*, plotted from Winkler's tables with the percentage of air laid out as ordinates and the temperatures as abscissae. A third curve, *C*, shows the difference between the two and curve *D* is plotted with inches of air pressure as abscissae. Comparing the percentage of air, as given by Mr. Orrok, in water at 187 deg. and 52 deg., the ratios agree within 4 per cent with those shown on the curve for Winkler's second table, (air-β_1). The percentage present in the hot-well water, based upon an assumed pressure in the steam space above the hot well taken by comparisons in Table 1 also corresponds very closely, that is, assuming a vacuum corresponding to a temperature 30 deg. above the hot-well temperature.

It may be claimed that the water tested was not under the absolute conditions required for the application of Winkler's tables. Strictly speaking this is true, but I believe the deviations do not seriously affect the consideration, and under any interpretation they do not approximate the ratio shown in Winkler's first table. There is not space here to discuss this question in detail, but if careful tests were made in practice, with the idea of obtaining the method of variation, I feel certain they would be found to conform so accurately that the curve mentioned for the variation in percentage of air present, although naturally not for the actual quantity, which varies widely, could be followed with reasonable safety.

It should be remembered that the absorption of air by water is a very slow process and does not compare with the speed of saturation of a space containing water at high temperature. We are apt to confuse these two as we are more used to considering the latter case.

Referring to Par. 7, Mr. Orrok does not give his method for determining the figure of $^1/_7$ for the air volume compared with

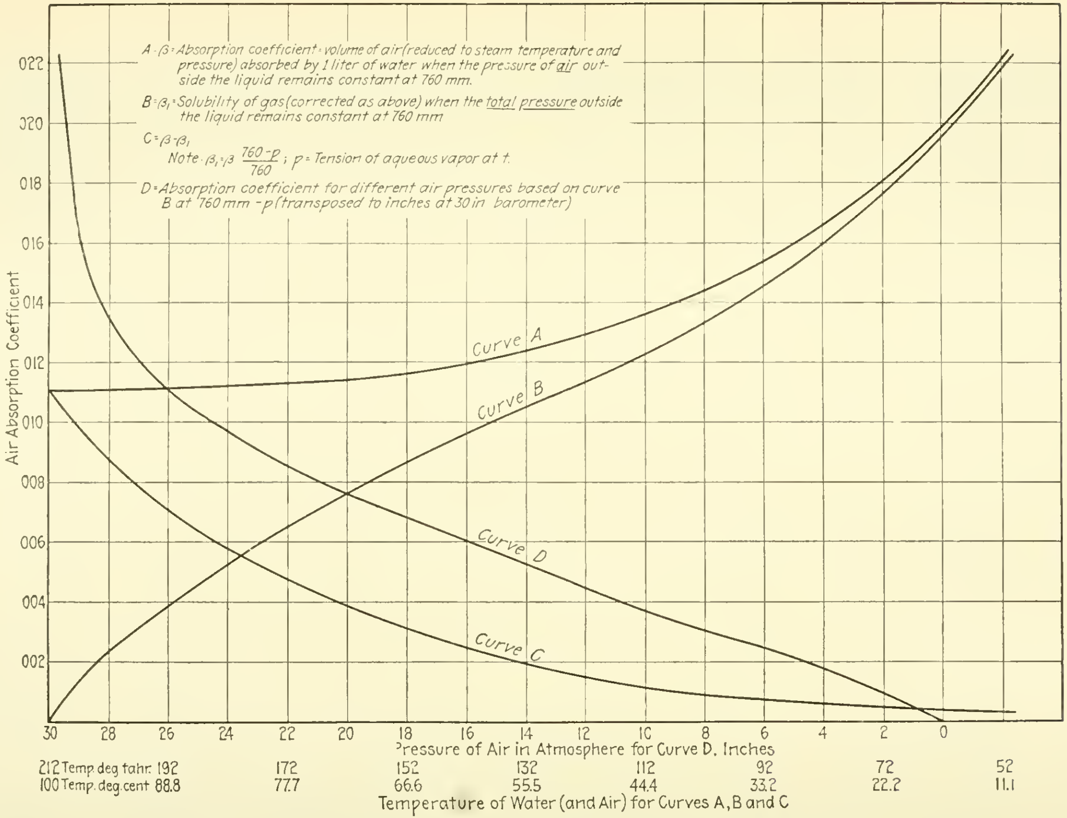

FIG. 7 CURVE SHOWING SOLUBILITY OF GASES IN WATER AT ATMOSPHERIC PRESSURE, CALCULATED FROM NITROGEN AND OXYGEN (WINKLER)[1]

that of the condensed steam. This is evidently an error, however, as the writer makes this figure 25 per cent, or one-fourth the volume of the condensed steam upon the usual basis of comparison of total pressures, or 10.2 per cent based upon the air pressure alone. With 2 in. absolute in the condenser, however, I believe the temperature of saturation would not be 81 deg. in the condenser, but more nearly 99 deg., or approximately within 2 deg. of the temperature corresponding to the vacuum; which would increase the volumetric percentages given above more than seven times. Several have misunderstood Par. 7 and assumed that the temperature of saturation in the condenser always corresponds to the hot-well temperature. They never do, except by chance, their determination being due to different causes. This is shown by Table 1, the temperature in the steam space averaging more than 30 deg. above the hot-well temperature, and even the cooled vapors at the air suction being at a higher temperature than at the hot-well.

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[1] See table in Castell-Evans Physico-Chemical Tables, vol. 2, p. 993, ed. 1911.

Regarding the gasometer, it is assumed that the water temperature and the air in the bell both have the external air temperature. These observations are of great interest in determining the air leakage in different plants, and of course this more or less determines the vacuum carried. However, an attempt to make too close a study of the air conditions in the condenser or in the vacuum pump, or the vacuum pump efficiency, from the observations as recorded in Table 1 should not be made, for the reason, as stated by Mr. Orrok, that in some cases the temperatures recorded are temperatures by convection from some other point of the apparatus, rather than of the air itself.

It is unfortunate that nothing definite is given as to the condition of the vacuum pumps and the vacuum they were able to maintain upon a closed suction. It is assumed that the various pumps are fitted with by-pass valves.

In Par. 27 the statement is made that the volumetric efficiency of the vacuum pump is very poor indeed. This statement should be qualified. The volumetric efficiency of such pumps is, on the contrary, very high, but in the cases observed apparently the vacuum pumps were set to operate at a speed that would give a displacement much greater than the required capacity. In that case it is evident that the unneccesary volumetric displacement would be filled with steam from the condenser, and therefore, when the comparison is made between the air in the bell and the pump displacement, the volumetric efficiency of the pump appears poor.

It is evident that considerable steam was carried into these vacuum pumps in the manner stated. Take for example the results given on the ninth line: Here the steam cylinder is shown as developing 23.32 i.h.p., the vacuum cylinder 10.58 h.p., but the equivalent of heat taken away by the jacket water amounts to 25.8 h.p. This shows a large condensation of steam with the consequent surrender of its latent heat, and it is much greater than would correspond to the amount of saturation corresponding to the temperature and pressure carried at the suction.

The condition of the air entering the vacuum pump is of great importance. If dry air were compressed adiabatically from 2 in. to 30 in. absolute, the air having an initial temperature of 60 deg. fahr., its ultimate temperature would be 680 deg. In the case of a vacuum pump of this type, however, there is always entrained moisture carried in with the vapors, and the heat of compression as latent heat evaporates a certain portion of this moisture, thereby greatly reducing the sensible heat. This is noticeable in the tests reported. It is therefore entirely useless to attempt any discussion of vacuum pump efficiency without much more complete information, and also without some attempt to determine its most efficient speed of operation.

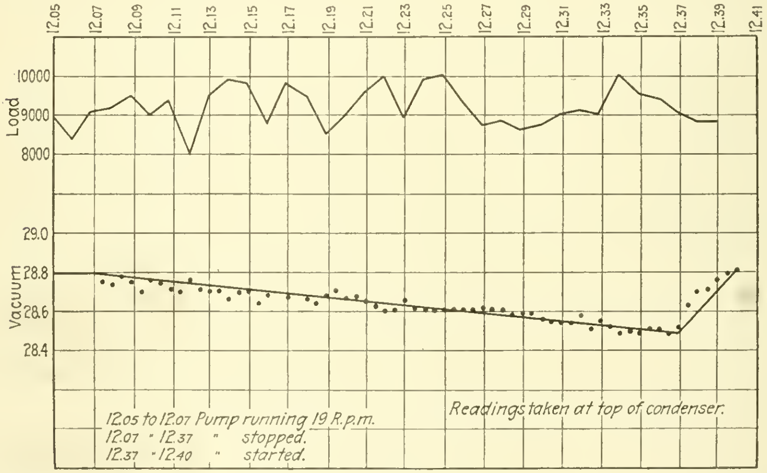

FIG. 8 VACUUM CURVE SHOWING THE EFFECT OF STOPPING THE VACUUM PUMP

The benefit of operating upon a closed system and cutting out the air as much as possible is unquestionable; Fig. 8 shows the effect of stopping the vacuum pump of one of the Boston Elevated units. We realized from past experience that the vacuum upon the system would not suffer seriously even if the dry vacuum pump were stopped temporarily, and James D. Andrews, chief engineer of the plant, kindly consented to stop the vacuum pump on one of the units for ½ hour, making ½-minute observations of the fall in vacuum. This unit was developing 9,000 to 10,000 kw. and carrying a vacuum equivalent to 1.03 in. absolute pressure when the pump was shut down. In ½ hour the vacuum had fallen only 0.32 in., or to 1.35 in. absolute. This curve is almost a straight line between the two points. Experiments at some length will be made later, discussing the air conditions under these circumstances.

The effect of air admitted into a condenser varies greatly with the point in the condenser at which it is admitted. It may also be admitted coincident with variations in the load and quantity of steam, or the temperature, or quantity of the circulating water, all of which affect the results in a degree varying widely with the design of the condenser and the pressure lost through the condenser. The design of the condenser should restrict such losses as much as possible, but conditions of space and load will freqently determine absolutely the features of design.

The Authur. Whenever tests have been made of the kind reported in this paper, they have resulted in increased vacuum, less leakage and in showing the operating man when and where to spend money for maintenance.

Vol. 2 of Castell-Evans tables is not generally known, and I thank Mr. Foran for calling attention to Winkler's table, which will be of great value to the profession.

The volumetric efficiency of air pumps depends on two things—clearance and the number of compressions. No engineer would think of compressing air to more than five or six atmospheres in one cylinder; but in the air pump with a vacuum of 29 in. we are using 30 or more compressions with correspondingly bad results in volumetric efficiency. Without doubt, all air pumps are handling more water vapor than they should, but until we can build air cylinders with less than ½ of 1 per cent clearance we must content ourselves with poor volumetric efficiency or go to two or three-stage air pumps.

Of the ten pumps referred to in the paper, six are high-speed, single, rotative valve pumps with the Weiss bypass; two are slow-speed, two-valve pumps with what corresponds to a bypass; and two are slide-valve pumps with the Weiss bypass.

Referring to Professor Everett's criticism, the curves in Fig. 6 are drawn as straight lines. The actual curves, however, must pass near the origin, and on this account the exponent (2) is offered, pending better determination. It is very simple to leave this factor out, as Professor Everett suggests, modifying the coefficient to allow for it.

Mr. Weir's light load, little air condition is strange to us where most of the air is leakage air. Even on large units the air coming over with the feed is rarely more than 1 or 1½ cu. ft. per min., and it is very rare that the total air can be brought below 3 cu. ft. per min. Practically all turbine plants are today using open or contact heaters on the suction side of the pumps.

Replying to J. J. Brown, the air in the bell is brought to atmospheric pressure by altering the counterweight and in most cases the water in the bell has so affected the air temperature that no correction need be made for this.

Referring to Table 1, the first ten lines refer to one condenser, the next four to a second, the next two to a third and the last three lines to a fourth condenser.

Referring to his third question, the curves in Fig. 3 were obtained by starting at a low load with the best vacuum obtainable and reading the drop through the condenser.

The load was progressively increased and the drops through the condenser were taken from the same instruments. During these tests, as the load was increased the vacuum decreased slightly.

There is a correction to be made in Par. 7 of the paper where the volume of air should be noted as between 20 per cent and 30 per cent, instead of $^1/_{17}$ of the feedwater volume.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

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FOREIGN REVIEW

In an early issue will be given a table for converting compound European units into American equivalents, such as cost in pfennigs per metric ton-kilometer to cents per ton-mile, calories per square meter heating surface to British thermal units per square foot, etc. It is believed that many will find such a reference table convenient. As heretofore data in the Foreign Review will be given in both the original and American units.

THIS MONTH'S ARTICLES

Among this month's articles will be found a description of various devices used for starting centrifugal pumps, and a short notice on Escher Wyss water turbines with lifts. The section on Internal-Combustion Engines contains an interesting article on spray carbureter testing giving what appears to be a practical and reliable method for testing the performances of the carbureter independently of the engine factors. Mr. Boobnov's notice on improving the reliability of naphtha engines by placing a strip of nickel in the ignition chamber is of practical interest owing to the simplicity of the device used. A. Henry's micromanometer has already aroused considerable interest in the European scientific press, owing to the simplicity of its construction and great sensitiveness: it is described under Mechanics.

While the figures in Mr. Mathot's article on the comparative advantages of using various types of prime movers in plants having waste wood available and requiring about 100 h.p. average, refer primarily to Belgian conditions and must be materially modified before being applied to similar cases in this country, they are of interest; particularly in the part referring to the gas producer and tests of a Diesel engine with Texas crude oil. In the section Steam Engineering will be found discussions on the Luminator process of feedwater purification; heat transmission in various types of economizers; description of a new type of traveling grate with undergrate blast provided with sectional air boxes, as well as of the Burkhardt type of water-tube boiler with its interesting way of combining the boiler proper and superheater. Mr. Keppert's article on smoke damages brings out the harm done by some kinds of smoke to vegetation, as well as the means that may be taken to counteract its influence (proper fertilization of the ground in affected districts); it shows also that it is not so much the color of the smoke, as its composition, that must be considered.

There are several articles to which attention is here called in the section Strength of Materials. Professors Bach and Baumann, on the basis of a careful experimental study, show that too much power is often used in riveting machines, with the result that the sheets are stressed beyond the elastic limit, and the riveted connection is made weaker than it would have been if smaller pressure were applied. Two articles by Messrs. Preuss and Busemann report data of experiments on the distribution of stresses in punched flat bars and direction of stress in inclined plates, the interest of both articles lying in the fact that they show the usual assumption of the uniform distribution of stresses to be entirely wrong, both cases being governed by more complicated laws which are briefly stated. Professor Mesnager's method of determining in advance the stresses arising in structures by polarized light effects is interesting in that it provides for the first time a way to apply this method to complicated structures (in this case a bridge of 320 ft. span) at a moderate expense. Professor Heyn's paper, of which only a brief abstract is given here pending the publication of its complete test in the original, will be of particular interest to steam turbine engineers.

Attention is called to the section Supplementary References in which additional information is given on subjects previously treated in the Foreign Review when the information is of only bibliographic interest, or for some reason cannot be used in abstract form. Whenever possible, abstracts or translation of articles previously abstracted in the Foreign Review are mentioned in this section when they appear in other periodicals in the English language.

The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Aeronautics

Doutre Biplane (*Le biplan Doutre*, P. James. *L'Aérophile*, vol. 20, no. 21, p. 484, November 1, 1912, 2 pp., 3 figs. *d*). Description of the Doutre biplane provided with the Doutre automatic longitudinal stabilizer. *Hollow wood* is used in its construction. To *keep the steering wires from getting lax and whipping*, as they do in certain positions in the present airships, all such wires are passed over sectors of the great arc on their way to the ailerons, this arrangement not only providing a support for the wires, but also insuring rapid and certain steering. The weight of the biplane with full equipment is 600 kg (1320 lb.); speed expected 90 km (55.9 miles) per hour.

On the Stability of Aeroplanes (*Sur la stabilité des aéroplans*, H. Mirguet. *L'Aérophile*, vol. 20, no. 21, p. 494, November 1, 1912, 2 pp., 2 figs. *dA*). Discussion of the problem of the stability of aeroplanes. The author believes that Alexandre Sée's proposal to use auxiliary planes is practical and satisfies all requirements. Mr. Sée proposes to use *separate surfaces* with the same normal incidence as the supporting planes, light and of small inertia, capable of instant displacement proportional to the effort applied, in fact such as one can see in the wings of the bird. The article describes also the Moreau Aerostable (Fig. 1) the interest of which lies in the fact that it is working, and as claimed successfully, on the principle of *pendular equilibration*. *B* is the handle of pawling; *C* lever pawl; *D* toothed sector; *E* large pinion for changing the speed from lower to higher; *F* handle of the hand brake of the pendulum; *G* pawl of the pendulum; *H* rack of the pendulum; *I* jaw releasing the rack; *K* hand release of the pendulum; *L* steering lever; *M* inertia mass; *O* countershaft for adjusting the rack; *P* storm lever; *R* double-acting rocking lever piloted at the center; *S* pendulum seat; *V* levers of the lateral ailerons. The handling of this system is described as follows: Suppose that the seat *S* is jambed by the pawl *G* on to the rack *H*. Then by operating the handle *B* the rise and descent of the aeroplane may be effected. Suppose further that an altitude of say 600 m (1968 ft.) has been reached and maintained. The pendulum seat is then released, the right wind found, and the lever *L* set, by means of the pawl *G*, on to the sector of the toothed wheel *D* (the pawl may advance half a tooth at a time, the sector having two sets of teeth staggered with respect to each other. By means of a chain the pinion *E*, made in one piece with the lever *L*, drives the little pinion *T* fixed under the pendulum seat with its shaft carrying the little connecting rod *X* engaging with the connecting rod *Y* which in its turn transmits the motion to the lever *Z* operating the rudder. To each variation in the position of the lever corresponds a variation in the incidence of the rudder. This apparatus is efficient in ordinary weather, but in storms the oscillations may become so large as to be dangerous: in such cases the storm lever *P* is used to brake the pendulum device. Should the engine suddenly stop, the mass *M* is projected forward by its inertia, acts on the jaw *I* which lifts the rack and jambs the whole apparatus. The apparatus is said to have been used in practice and proved efficient under normal conditions of weather.

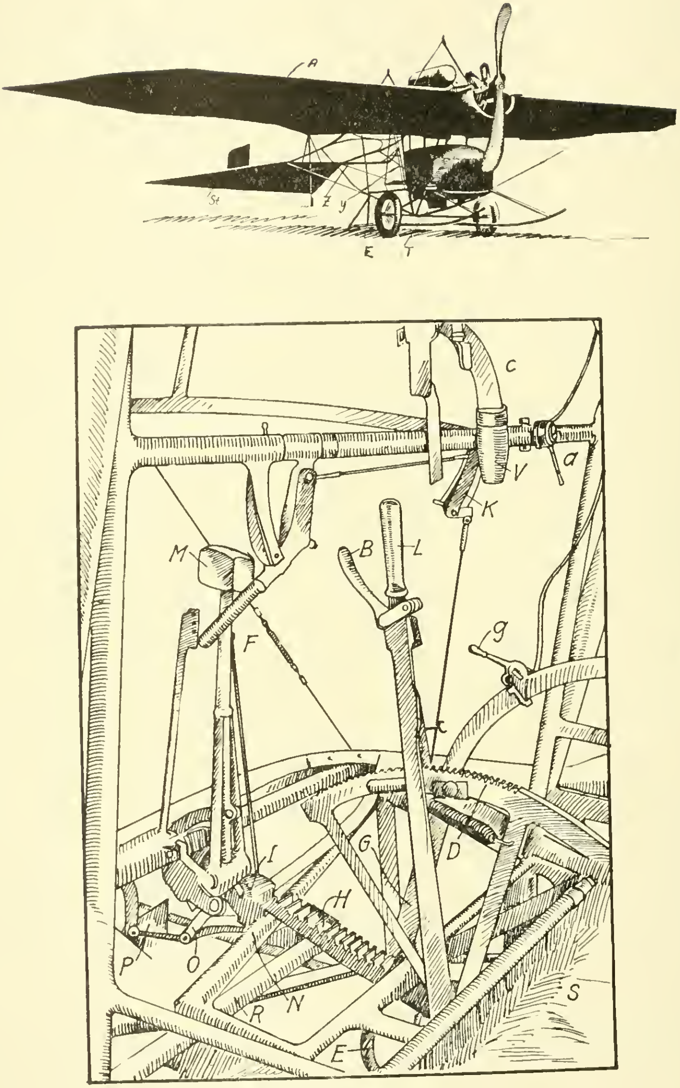

Fig. 1 Moreau Aerostable

Air Machinery

Tests of a Turbo-Compressor at the Westerholt Mine. (*Untersuchung eines Turbocompressors auf der Zeche Westerholt. Glückauf*, vol. 48, no. 47, p. 1913, November 23, 1912. 3 pp., 2 figs. *de*). Corrected data of *tests of an air compressor plant* at the Westerholt mine, Ruhr district, Prussia, from a communication of the Essen office of the Association for the Inspection of Steam Boilers. The turbine driving the compressor is so arranged as to be able to work both with live and exhaust steam, while the compressor can take in either 10000 cbm (say 35000 cu. ft.) of air per hour and compress it to 6 atmospheres gage, itself running at 4400 r.p.m., or it can run at 4200 r.p.m., and compress to 5.5 atmospheres 5000 cbm of outside air. The consumption of steam was guaranteed to be: for exhaust steam only, when handling 10000 cbm, 1.4 kg/cbm (say 0.088 lb. per cu. ft.), for 5000 cbm, 1.78 kg/cbm (say 0.112 lb. per cu. ft.); for live steam only 0.69 kg/cbm and 0.88 (say 0.04 and 0.055 lb. per cu. ft.) for the full and half load respectively. The actual test values are slightly more favorable than these. The article contains full data of the test.

Hydraulics

Starting of Centrifugal Pumps (*Das Anlassen der Kreiselpumpen*, A Schacht. *Die Fördertechnik*, vol. 5, nos. 11 and 12, pp. 252 and 269, November and December 1912. 5 pp., 20 figs. *cd*). Descriptions of various devices for starting centrifugal pumps which, by their own rotation cannot create the initial vacuum required for the suction of water. The simplest method, filling the pump for the first time with water by hand, cannot be applied to large pumps or even to small pumps with long suction piping. In small house pumps a hand-driven reciprocating pump may be used for starting, or as described in the U. S. patent No. 804774, a special reservoir may be provided connected with the pressure pipe of the centrifugal pump, and having a float-valve for keeping the reservoir always full of water. For large pumps the device described in the British patent No. 17053 (Fig. 2A) may be used: the vertical pump shaft is extended downwards and carries a second blade wheel located so as to be always below the lowest level of the water and driving water up to the large pump wheel. The same patent covers also the device shown in Fig. 2B where a special reservoir is inserted in the suction piping; at starting the pump takes water from the reservoir, and thereby produces a partial vacuum in the long pipe, causing water to rise from the lower level; the device will of course work only if the reservoir and its connections are absolutely air tight. A German patent (No. 21055) covers an arrangement devised principally for dredger pumps wherein an auxiliary piping supplies water to the suction piping at such a rate that all the air is driven out of it, and it is filled with water. Fire engine centrifugal pumps (German patent No. 224223) must be started rapidly and certainly: a closed reservoir previously filled with water is emptied through the pump and produces there a partial vacuum under the action of which the suction piping is filled with water driven by atmospheric pressure. While the pump is being started, the water from the reservoir is used for fire fighting purposes, and thus not a single moment is lost.

There are several patents covering the application of the ejector principle to the starting of centrifugal pumps, partial vacuum in the suction piping being created by a jet of steam or water. Fig. 2C shows how this is embodied in the British patent No. 25988: the water under pressure for the ejector is supplied by a little auxiliary pump driven from the main pump shaft; as soon as the main pump begins to work, the auxiliary one is cut off. Fig. 2*D* (German patent No. 216293) shows the same principle in a more complicated execution. Two centrifugal pumps are connected in series, one of them sending the water through an ejector and thus producing the suction required for starting. In practice it was found that the efficiency of high grade vacuum pumps was improved when the jet of water sent by the second pump through the ejector acted intermittently, as when the jet is shut off at short intervals of time in such a manner that separate little jets are shot out from the ejector into a nozzle; the air is then caught between the jets and expelled with greater certainty. In the arrangement shown in Fig. D, a special interrupter is provided, but another arrangement has been patented in which the part of interrupter is performed by the blade wheel of the auxiliary pump. The leading idea of the starter design in the centrifugal pump of Thyssen & Co., of Mulheim-Ruhr, Germany, (E) was to obtain a high efficiency by the use of a jet of water of large cross-section, and at the same time to protect the outlet nozzle from becoming clogged with dirt. The cold water is driven by two blade wheels into annular nozzles arranged along the periphery and comes out of them in a thin sheet which is taken up by a stationary combining nozzle and transformed into a jet; this jet in its turn acts as an ejector element in expelling the mixture of air and steam and thus producing a partial vacuum. The annular nozzles rotate at as high a speed as the friction against the wheels and water permits; particles of dirt or wood which get in can find no purchase between the stationary and rotating walls, and are rapidly ground up by the nozzle wall; this happens even with long wooded chips 4 mm (0.16 in.) thick. The construction of Gustav Bölte in Oschersleben (F) patented in Germany (No. 239345) is particularly adapted to vertical pumps. The gas and liquid flow axially which allows the gas and liquid ducts to run side by side without intersecting; the ducts for the liquid may be, e.g., bent backward, while those for the gas forward or radially. On the horizontal wall *a* of the runner the axially directed outlets of the gas ducts *b* and liquid ducts *c* alternate, the liquids acted on by the pump reaches the ducts in the nozzle body *d*, and sucks with it gas through *b*, gas and liquid pistons in *d* following one another. The gas collects in *e* and escapes through *f*, while the liquid returns to the suction side of the ducts. The space *e* should be large enough to permit the water to absorb the air; there is further a tendency for the water to heat up and start evaporating: these appear to be the disadvantages of this construction.

The article describes also the devices of Delahaye, Rateau, and Koerting, known in this country, and those covered by the U. S. patents Nos. 820779 and 819237 which do not need abstracting here. Mention is made of a device known as Hydraulic Air Pumps Patent Scholl and manufactured by Böckel & Co., Mannheim, Germany, in which water under pressure is used for the evacuation of air, the air pump being automatically cut out as soon as the centrifugal pump begins to work; this device is described only in a very cursory manner.

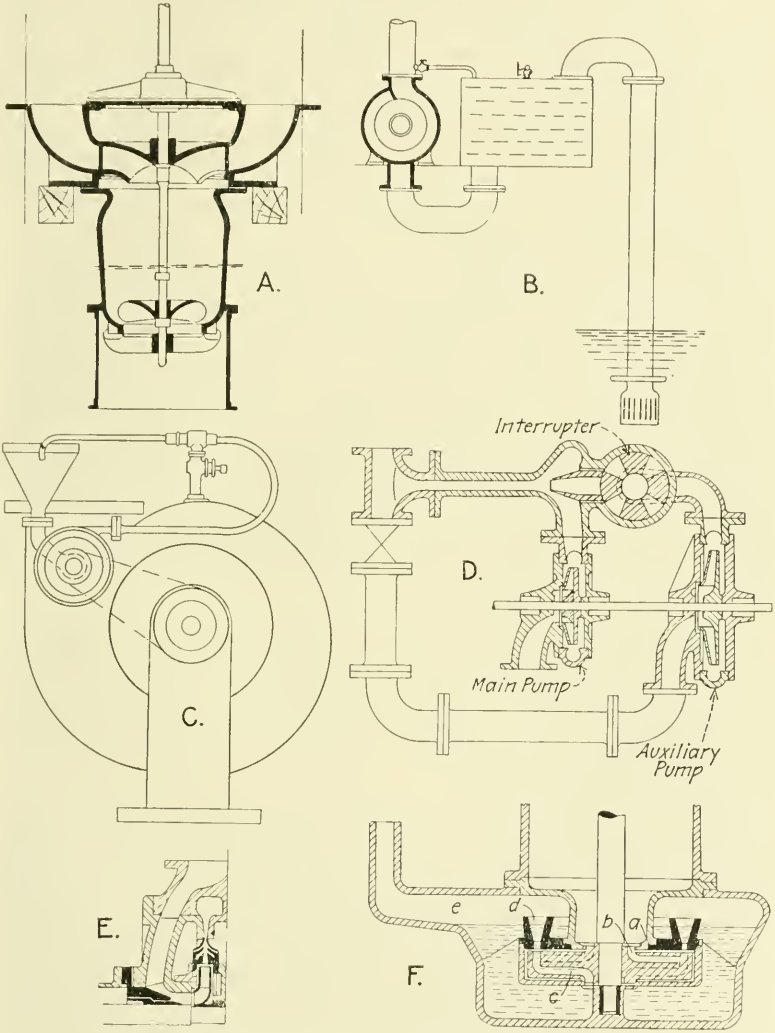

Fig 2 Devices for Starting Centrifugal Water Pumps

WATER TURBINES WITH LIFTS (*Wasserturbinen mit Heber*, H. Keller. *Die Turbine*, vol. 9, no. 5, p. 80, December 5, 1912, 3 pp., 3 figs. *d;* same in French in *Génie Civil*, vol. 62, no. 5, p. 92, 1 p., 1 fig. *d*). Description of the Escher Wyss & Co. system of turbine plant construction used in cases where it is desirable, with a usually low head of water, to have the driven machine, say the generator, directly connected to the turbine, and at the same time protected from flooding at high water. To do this, the axis of the turbine is placed near the high water level, the water being raised by special lifting apparatus. The artificial drawing off of the air by suction by means of the suction pipe of the turbine itself is one of the characteristics of this system. The apparatus described is not new, plants having been installed on this system as early as 1908. No data as to the amount of power required to withdraw the air or as to the general efficiency of the plant are given in either of the two articles.

GRAPHICAL REPRESENTATION OF THE WORKING PROCESSES IN CENTRIFUGAL PUMPS (*Darstellung der Betriebsvorgänge bei Kreiselpumpen*, H. A. Janssen. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 47, p. 1895, November 23, 1912. 6 pp., 9 figs. *tA*). Starting with the well-known graphical methods for determining in case of centrifugal pumps the mutual relation of the number of revolutions, delivery head, output and efficiency, the author shows how it may be also applied to the determination of the power of the driving engine, its moment of torsion and specific output, as well as how such diagrams may be used. He also draws diagrams showing the working process of any centrifugal pump of given construction as far as the mutual relation of the above named variables is concerned. Several numerical examples are given to illustrate the author's methods.

Internal Combustion Engines

SINGLE-SCREW MOTOR SHIP "ROLANDSECK" OF THE GERMAN NAVIGATION COMPANY "HANSA" (*Einschrauben-Motor-Frachtschiff "Rolandseck" für die Deutsche Dampfschiffahrts-Gesellschaft "Hansa*," C. Kielhorn, *Dinglers polytechnisches Journal*, vol. 327, nos. 49-50, pp. 772 and 791, 6 pp., 5 figs. *d*). Description of a Diesel engine freighter. Cp. *The Engineer* (London), November 22, 1912.

HIGH-SPEED DIESEL ENGINES (*Moteurs Diesel à marche rapide*, Prof. G. Supino. *Electro*, vol. 11, no. 11, p. 167, November 1912, 3pp., 2 figs. *e*). Data of experiments made by the author at the Royal Engineering School, Milan, Italy, with a Langen & Wolf high-speed Diesel engine; of interest in view of the controversy as to whether high-speed Diesel engines are practical or not. The author found (data from one of the 7 tests reported in the article are used in this abstract) that with 378 r.p.m. the engine developed 79.5 e.h.p. at the shaft, with a consumption of 206 grams (0.45 lb.) of fuel per e.h.p-hr. Heavy oil was used as fuel, of density 0.93, and heat value 10200 calories (18360 b.t.u. per lb.).

POWER GAS PRODUCERS FOR LIQUID FUELS (*Kraftgaserzeuger für flüssige Brennstoffe*, Gwosdz. *Die Gasmotorentechnik*, vol. 12, no. 9, p. 137, December 1912, 3½ pp., 7 figs. *d*). Description of gas producers for liquid fuel; only American types are described.

2000-H.P. GAS BLOWING ENGINE (*2000-PSe Gasgebläsemaschine*, Ed. Kaschny. *Zeits. für Elektrotechnik und Maschinenbau*, vol. 15, no. 50, p. 533, December 11, 1912. 2½ pp., 1 fig. and 1 sheet of drawings. *d*). Description of the Maschinenfabrik Augsburg-Nürnberg type of large gas blowing engine for which a very high degree of reliability is claimed.

INDICATOR FOR SPRAY CARBURETERS (*Indikator für Einspritz-Vergaser*, G. Bergman. *Der Motorwagen*, vol. 15, nos. 17, 21, 29, 31, 33, pp. 431, 515, 671, 713, 757, June 20, July 31, October 20, November 10 and 30, 1912. *deA*). For a general discussion on the subject of carbureter tests see *Some Tests on Carbureters*, by George W. Munro, *The Journal*, March 1912, p. 343, and *discussion* of same in *The Journal*, August 1912, p. 1208. The imperfection of the method applied to the test of carbureters lay, however, in the fact that, as pointed out by Mr. Munro, the carbureter is used only in connection with an engine and has to be tested in use upon it, thus introducing engine characteristics into all results, while on the other hand, the performance of the engine cannot be determined free from carbureter factors. The article of Mr. Bergman shows a way to arrive at the determination of the carbureter characteristic practically independent of that of the engine to which it is attached. The basic characteristic of the method applied is the use of a carbureter which, in addition to the usual fuel port, is provided with a measuring opening of the same form and arrangement, but with mechanically operated opening and closing. The manometer attached to it is therefore connected with the interior of the carbureter only during the period when the valve gear leaves the respective passage open, and registers only that phase of the process in the carbureters which corresponds to the particular moment under investigation. By changing the moment of opening of the carbureter by suitable adjustment of the valve gear so as to register phase after phase, the entire series of pressure variations may be ascertained. The reliability of this process is shown by Fig. 3A which is made up of 17 superimposed diagrams: variations are of a purely local character, and so slight that they affect neither the area of the diagram, nor the shape of the curve expressing the law of pressure variations in the carbureter. The carbureter as used for these tests is shown in Fig. 3B. The mixing chamber is tube-shaped; the fuel pipe crosses it normally to the direction of the air current, and may be displaced axially by a screw arrangement shown in the drawing; the position of the fuel pipe may be read on a special scale attached to a stirrup screwed on the fuel pipe. This stirrup runs in guide-blocks; according to its displacement, the fuel pipe rotates, thus producing variations of the angle between the fuel and measuring openings on one hand and direction of the air stream on the other. The measuring opening is regulated by means of a rotating inside slide valve. As long as a certain phase of the process is being investigated, especially in regard to its functional relation to various regulations of the engine to which the carbureter is attached, the slide valve is made to rotate at the same speed as the engine, and the port in the valve and the measuring opening are made to superimpose always at the same position of the piston. The slide valve may be set so as to correspond to any desired position of the piston. When the slide valve rotates somewhat slower than the engine shaft, the carbureter

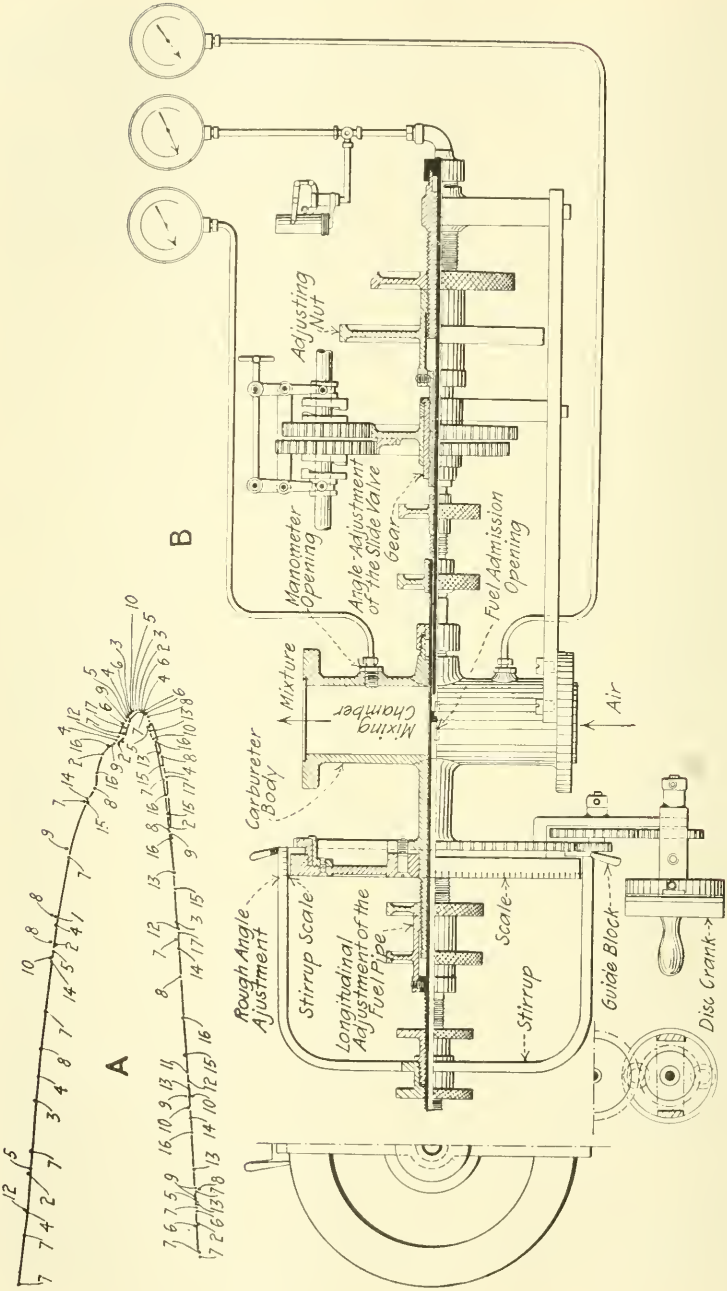

FIG. 3 CARBURETER INDICATOR AND DIAGRAMS

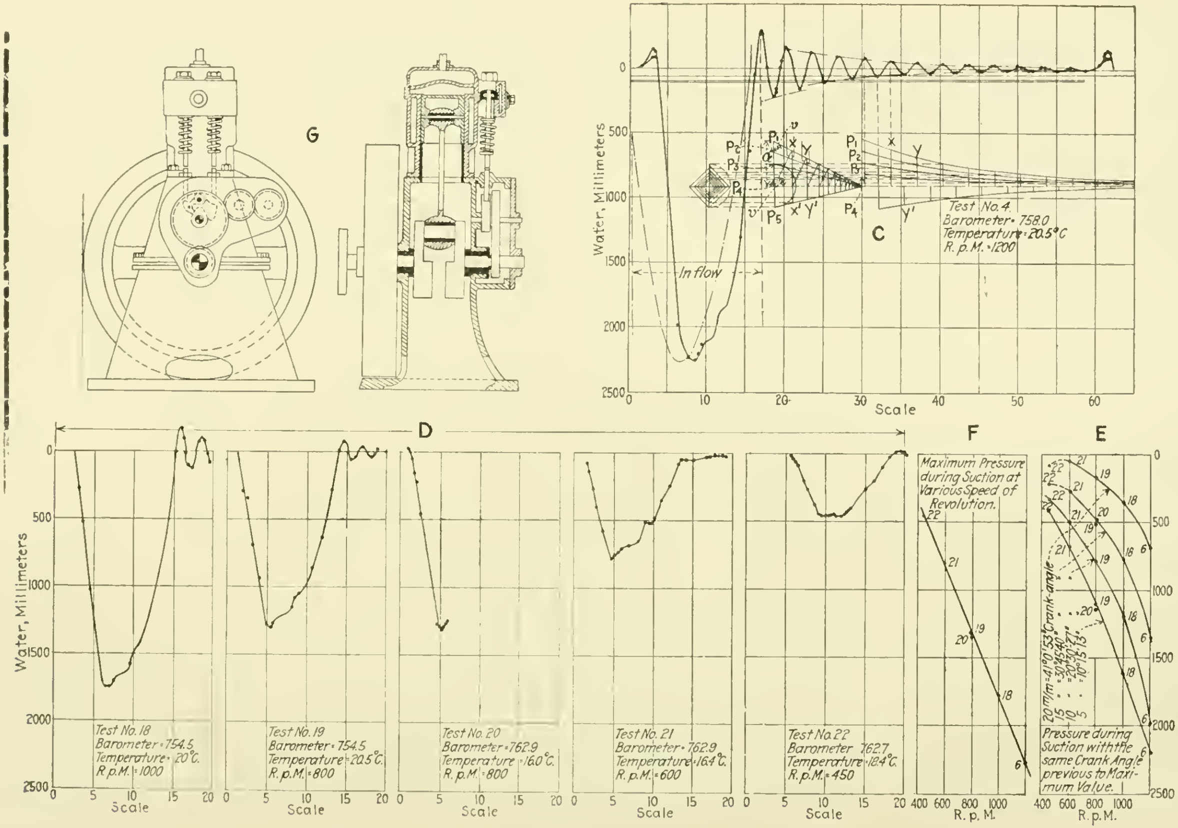

Fig. 3 Carbureter Indicator and Diagrams

pressure registered represents different phases for each revolution, while the average pressure may be obtained by placing the slide valve opening opposite to the measuring, and making the slide valve stationary. This arrangement proved to be very convenient; the presence of the slide valve did not interfere with the free working of the carbureter, and produced neither eddies nor additional oscillations in the gaseous mass, while all the phenomena which affect the performance of the fuel nozzle act in the same way with respect to the measuring opening, and are registered by the manometer.

Fig. 3C gives the *carbureter diagram. Back pressure of exhaust-gas products.* The inlet valve rises after the upper dead center OT is passed; the opening moment is marked EO; there is still an underpressure in the cylinder, resulting in a pressure surge in the carbureter. During the action of the back pressure of exhaust-gas products the motion of the piston accelerates (its velocities are indicated on the diagram by dotted lines); the gases in the cylinder expand, and the pressure surge rapidly goes down, this return movement being still more intensified by the inertia of the gas column which must first change its direction of motion in order to follow the piston: owing to this, the curve is much sharper than that of the piston velocities. After the piston passes through its maximum velocity, its motion begins to retard, but the gas motion, i.e. pressure variation, still continues in the former sense. When therefore the piston reaches its lower dead center (UT_1 UT_2), the gas column still continues to flow as before, the pressure rises above atmospheric and the valve begins to close (the pressure above atmospheric in the cylinder is actually somewhat less than in the carbureter diagram). The course of the charging impulse depends on the regulation of the admission; in the main it ought to follow the piston velocities, provided they are drawn to a correct ordinate scale. The irregularities which appear in Fig. 3 are due to resistances in the piping and valves, or lost motion in the valve gear.

The engine attached to the carbureter was electrically driven as an air pump, at an average speed of 1200 r.p.m., but actually varying from 1190 to 1210. The diagrams taken are shown in Fig. 3D, where the various curves vary only in the ordinate scale, but otherwise belong to the same family, or are derived from the same function preceded by different coefficients depending on the number of revolutions n:

$$f_n\ (2x) = c_n\ f_{no}\ (2x)$$

where f_{no} is the impulse function. This equation shows that all corresponding points or phases of two diagrams are in the same ratio of ordinates (proportionality of ordinates). If the ordinates of respective points of the diagrams be plotted as functions of the speed (Fig. 3E), the chords of all the curves will intersect in the same point. Deviations from this law may be due to irregularities of working, variations in resistance of flow, or resonance phenomena. In Fig. 3F the peaks of the curve are plotted as functions of the number of revolutions, and the pressure deflections are found to be proportional to the speed. This law holds good only within the range of speed used in this case, and undergoes material changes at considerably higher speeds. Pressure surges decrease more and more as the speed decreases.

Altogether the above diagrams show that the character of the suctlon impulse as expressed by the equation

$$p = c_n \cdot f_{no}\ (2x)$$

is fairly well able to oppose all ordinary influences tending to alter it; artificial regulation, such as throttling, changes the shape of the curve, as the author shows in a further set of curves.

While this part of the article, as well as that referring to errors due to the measurement of the air in the investigation of the processes occurring in the carbureter cannot be abstracted here owing to lack of space, attention is called to the fact that the author's method gives a practical and certain way for investigating the efficiency of carbureters and valve gears; the author claims that even the slightest irregularities in the valve gear action may be thus detected and traced to their origin.

Causes of Irregularities in the Working of Two-Stroke Cycle Naphtha Engines and their Elimination (*Prichiny kaprizov dvookhtaktnykh neftyanykh dvigateley i ikh oostraneniye, Dvigatel*, vol. 6, no. 21, p. 353, 1912. *p*). Mr. B. A. Boobnov, of the Kiev Polytechnic Institute, Russia, states that small two-stroke cycle naphtha engines find a wide application in the industry in Russia, but their still larger spread is prevented by frequent irregularities of working, such as loss of power, loss of economy of operation, and, what is the most annoying, stoppages. The general construction of the engine is so simple that trouble could be looked for only in connection with the ignition chamber, and the writer both from his own investigations and tests made at some of the exhibitions of internal-combustion engines recently held in Russia noticed that sometimes not enough heat is developed during the working of the engine, with the result that products of incomplete combustion are formed and deposited on the inner surface of the ignition chamber in the form of coke; this coke reduces the thermal capacity of the ignition chamber and thereby causes irregularities in the working of the engine. The author claims to have eliminated this tendency by the use of what he calls a *catalyst*, in this case an element of high specific heat, to promote more complete combustion. There were three metals that could be so used: platinum, copper and nickel, but platinum is too expensive, and copper volatile; nickel was therefore used, a strip of it being placed on a wire of the same metal in the ignition chamber (the wire was used in order to reduce direct contact between two bodies of different specific heats). This increased the efficiency of the engine and economy of operation, and eliminated smoke and uncalled-for stoppages of the engine. No data as to the size of the nickel strip are given, the author simply stating that he determined it by guessing, as he could find no information in the literature as to what it should be. The strip is called a catalyst because it accelerates the process (in this instance that of combustion) without actually taking part in it.

Mechanics

Micromanometer (*Micromanomètre*, A. Henry. *Comptes Rendus des séances de l'Académie des Sciences*, vol. 155, no. 22, p. 1078, November 25, 1912. 2 pp., 1 fig. *d*). This manometer is a modification of that of Kretz. The author noticed that the latter grew more sensitive as the densities of the two liquids approached each other, and substituted for the two liquids a single one, with an air bubble inside, at *b* (Fig. 4). The bends *C* and *C′* serve to keep the air bubble from escaping. It has been found that the friction between the air bubble and the surrounding media, when the apparatus is properly arranged, is extremely small. Water cannot be used as the liquid because it attacks the glass, and produces a rough surface of contact for the air bubble. The most convenient liquid to be used was found to be carbon tetrachlorate, which is but slightly viscous, possesses a low surface tension, is not affected by air, and is not inflammable. The apparatus is extremely sensitive: the author in his tests has found that it may be relied on to indicate a variation of pressure of 1/200 mm (say 0.0002 in.) of water. In one of the apparatus a variation of pressure of 0.5 mm (0.0197 in.) of water produced a displacement of the air bubble of 120 mm (4.71 in.), with a probable error not exceeding 1 per cent in the estimation of a pressure of 0.5 mm (0.0197 in.) of water.

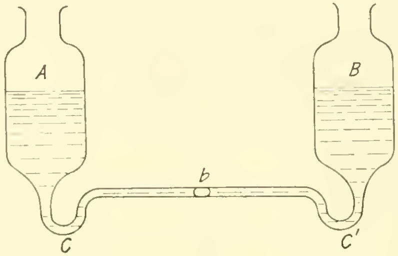

Fig 4 Henry Micromanometer

Power Costs and Fuel

Critical Study of an Installation of a Power Plant of 100 H.P. in a Factory Having Large Quantities of Wood Waste Available (*Etude critique d'une installation de force motrice de 100 chevaux dans une usine disposant de déchets de bois en grande quantité*, R.-E. Mathot. *La Technique moderne*, vol. 5, no. 12, p. 439, December 15, 1912. 4 pp., 2 figs. *cep*). Investigation of the problem as to the kind of prime mover that would be the most convenient for a factory requiring about 100 h.p. and having large amounts of wood waste. A steam engine would not be economic because its combustion is fairly rapid, and special attendance would be required to shove the wood shavings and chips into the furnace; besides, the amount of wood waste would probably be insufficient to feed the engine, and additional coal would have to be used, thus increasing the cost of power. An anthracite gas producer does not use the wood waste at all, but requires a rather expensive fuel. A much better plan would be to use a special gas producer for the burning of wood waste, such as the Crossley type. The author gives full data of the Crossley gas producer and producer engine for use of wood waste showing that 1.20 kg (2.64 lb.) of wood waste is burned per e.h.p-hr., though this consumption may rise to 1.50 kg (3.3 lb.) per h.p-hr. with very wet wood. When burned in a steam boiler furnace, the same material would be burned at the rate of 3 to 4 kg (6.6 to 8.8 lb.) per h.p-hr. Under Belgian conditions the cost of running a Crossley gas producer plant would be as follows (with the initial price of the installation for 100 h.p. at 30,000 fr., or roughly $6000):

	Fr.	$
Interest and depreciation in 10 years at the rate of 13 per cent per year on 30,000 fr./$6000	3900	780
Maintenance at the rate of 4 per cent of the cost of the engine and gas producer alone (25,000 fr./$5000)	1000	200
Attendance: One engineer	1500	300
One helper to load the waste into the furnace	700	140
Combustible (wood waste)	No cost.	
Lubrication	300	60
Various minor expenses	200	40
Total	7600	1520

Or at the rate of 60 h.p. average during 300 days at 10 hours per day, the cost per e.h.p-hr. comes to fr. 0.042, or $0.0084, which, at least under Belgian conditions, is more economical than using a Diesel engine with tar-oil at 8 fr. per 100 kg ($14.6 per short ton).

The second part of the article gives a brief description and some data of tests of Diesel engines built by the Swedish Diesel Engine Company of Stockholm (Altiebolaget Diesels Motorer) and provided with Hesselman atomizers (for a description of the Hesselman Atomizer see *The Journal*, March 1912, p. 417). During these tests the number of revolutions was registered for each load by means of an integrating speed-counter; the fuel consumption was determined by using instead of the usual fuel tank a special tank with the fuel previously weighed; the length of each test measured by a chronometer; cooling water consumption determined by a meter; indicator diagrams were used to control the conditions of the test, but the action of the indicator could not be controlled sufficiently to make it possible to use the diagrams for determining the power indicated and the mechanical efficiency.

The first of the engines, having three cylinders, was loaded by means of a Heenan and Froude hydraulic brake.

Texas crude oil was used, having a density of 0.885 at 18 deg. cent. and 2.2 per cent of non-combustible matter. The other engine tested was a single cylinder engine, with German tar-oil used as fuel.

The following data have been obtained (the original article contains data from five tests of the motor *A*, and four tests of the motor *B*: only two tests for each engine are quoted here): *A* is a three cylinder 135 h.p. using Texas crude oil; *B* a one cylinder, 45 h.p. engine, using German tar-oil.

	Engine *A*.		Engine *B*.	
Test No.	1	2	1	2
Length of test, min	60	30	30	30
Load	full	half	full	half
Brake load in kg/lb.	157/344	77.5/172	97.7/214	49.7/109.4
R.p.m.	266	272.7	268	273.2
Work at the brake, e.h.p.	139.18	70.7	45.3	23.5

Oil: Total consumption, kg/lb.	25.3/55.6	6 91/15.22	4.38/9.66	2.85/6.25
Per b.h.p-hr., gr/lb.	181.7/0.4	196.5/0.435	193/0.425	242.5/0.535
Cooling water per h.p-hr., 1/gal.	10.7/2.78	13.1/3.41		
Temperature of water at leaving engine, deg. cent./fahr.	60/140	58/136.4	64/117.2	69/156.2
Compression in the cylinder, kg per qcm/lb. per sq. in.	39/555		41/583	
Thermal efficiency	0.325		0.346	

These tests have shown the possibility of overloading the engines 23 per cent above normal load. The consumption is remarkably low, especially in the case of the small engine to which tar oil was delivered by a single pump, without admixture or preheating.

The author gives the following data as to the cost of running a 100-h.p. Diesel engine of the Polar-Diesel type, delivering on an average 60 h.p. (under Belgian conditions); the prices are in fr./$, taking $1 = fr. 5:

TABLE 1 COST DATA, 100 H.P. POLAR-DIESEL ENGINE

	Fr.	$
Interest and depreciation at the rate of 13 per cent per year on 29,000/5800	3770	754
Maintenance charges at the rate of 4 per cent per year of cost of engine (27,000/5400)	1080	216
Attendance: One engineer	1500	300
Fuel, at the rate of 190 grams (0.42 lb.) per h.p-hr., at 8 fr. per 100 kg ($14.6 per short ton), for 60 h.p. 300 days at ten hr. a day	2736	547.2
Lubrication	300	60
Various minor expenses	114	22.8
Total	9500	1900
Per h.p-hr.	0.0527	0.0105

The author shows in another table that the cost of power with a gas producer of the suction type would be only fr. 0.0427 ($0.0085) and therefore from the point of view of economy would appear to be the most advantageous; the Diesel engine presents, however, important advantages in the small floor space that it takes, its reliability of operation, ease of handling the fuel, absence of smoke, etc. and is an ideal prime mover where the cost of fuel is of but secondary importance.

Coal Storage and Costs (*Über Kohlenlagerung und ihre Kosten*, R. Nübling. *Journal für Gasbeleuchtung*, vol. 55, nos. 49 and 50, pp. 1193 and 1222, 7 pp. 7 fig. and 2 sheets of drawings. *p*). General discussion of the question of coal storage containing a good review of the literature of this question, mainly German. A bibliographic list is appended, as well as several tables showing the loss of gas production and heat value of coal as a function of the length of storage. Bibliography appended.

Steam Engineering

"Luminator" as Boiler Scale Preventive ("*Luminator*" *gegen Kesselstein*, E. E. Basch. *Chemiker-Zeitung*, vol. 36, nos. 148 and 150, pp. 1435 and 1461, December 10 and 14, 1912. 3 pp. *gt*). Critical discussion of the "*Luminator*" *process for removing boiler scale* (for description of this process see *Society of Chemical Industry*, vol. 31, pp. 57-60, 1912, and vol. 30, pp. 933 *f-f-*). The author analyses various theories presented by different writers for the explanation of this process, as well as its efficiency, and finally concludes practically as did the Prussian Ministry of Industries and Trade, which stated in its report for 1910 that the Luminator process "belongs to the class of apparatus in the experimental stage. As long as it is not explained what is the cause of its action, its results must be considered as accidental." The author denies the possibility of the aluminum particles being torn off the plate and acting on the particles of matter forming the scale, and says that in 1907 he had seen in Hamm i.W., Germany, an installation for the extraction of iron from feedwater in which the water containing considerable amounts of iron was passed through a heap of beech branches and then treated in the usual manner by aeration and filtration, with the result that when fed to the boiler, it produced plenty of sediment, but no hard scale. He concludes therefore, that there are certain kinds of water which may be cleaned by simple driving through any material whatever, but that the aluminum particles have no part in producing this result, even if it were known that there were any in the water treated by the Luminator process which, the author states, has not yet been proved. He is inclined to classify the action in the Luminator process among phenomena analogous to the case of a supersaturated solution in a state of unstable equilibrium being transferred to the state of stable equilibrium by introducing into it what is known as ion. In the Luminator process tiny crystals of calcium carbonate which reach the boiler from the Luminator plate act as the ion.

As to the behavior of the most important element of feed water, as far as the formation of scale is concerned, viz. calcium sulphate in luminated water, Dr. Hilliger states that owing to the application of the Luminator process, gypsum can remain in solution up to that concentration at which it automatically separates out owing to supersaturation; according to the author, however, Dr. Hilliger takes the concentration limit too high, since in a closed boiler all gypsum ought to separate out at temperatures varying according to different authorities from 140 to 150 deg. cent. (284 to 302 deg. fahr.). In a tubular boiler in which the entire water is evaporated at least once in 12 hours, the formation of gypsum scale would therefore begin after a single day of operation.

The author believes therefore, that, taking all conditions into consideration, the Luminator process will give a scale-free boiler running only in exceptional cases, and even then the formation of sediment instead of scale is not always quite desirable since it may lead to the clogging of boiler fittings, and overheating and outward bulging of boiler sheets. Besides the only reliable way to remove sediment is by frequent and generous blowing out of the boiler, and that involves considerable losses in heat and boiler water.

The author severely criticises the tests lately made in Vienna by the Society for the Inspection and Insurance of Boilers at the demand of the Austrian Patent Office which have shown that with the Luminator process applied fully (aluminum plate and solar light) only 1/5 of the scale formed without it has been found in the boiler; when the process was used only partly (aluminum plate, but no solar light) twice as much scale was formed as when the process was fully applied. The author analyses the methods of conducting these tests, and concludes that the boilers were working under conditions quite unlike what they would be subjected to in actual practice, while it was even possible that the addition of water after the drawing of the fire might have produced the loosening of some of the scale (he does not explain, however, why this should happen in the case when the Luminator process was applied). The question as to whether the light has anything to do with the efficiency of the process is not considered by the author. A full bibliography of this process has been prepared by the Library of the Engineering Societies.

On the Influence of the Material and Thickness of Walls of Economizer Pipes on the Utilization of Heat (*Über den Einfluss des Materials und der Wandstärken von Ekonomiserrohren auf die Wärmeausnutzung*, M. R. Schulz. *Braunkohle*, vol. 11, no. 37, p. 590, December 13, 1912, 3 pp., 1 fig. *cp*). Critical discussion of Mr. Hanff's paper abstracted in *The Journal*, November 1912, p. 1893, with Mr. Hanff's rejoinder. The author claims, on the basis of tests made by the Bavarian Association for the Inspection of Steam Machinery that circulation economizers require from 10 to 15 per cent less economizer surface than e.g., Green economizers, and that consequently even with cast-iron economizers the water velocity plays an important role, a fact not taken into account by Mr. Hanff. The author claims also that Mr. Hanff's formula cannot be applied equally well to wrought-iron and cast-iron economizers, since entirely different assumptions are made in the design of the former; the coefficient of heat transmission in the Schulz economizer has been found to be nearly twice as high as in cast-iron economizers. The main point however is what amount of heat is transmitted through a unit of surface of the economizer, and this question is answered by the curves in Fig. 5 taken from the author's book "*Über Ekonomiser.*" These curves have been traced on the basis of the following considerations: the absorption of an economizer is a function of the temperature of the flue gases at the economizer entrance, and the velocity of the gases; there are therefore four curves; two for natural draft and two for forced, because in the latter case the heat transmission may be increased by raising the velocity of the flue gases.

Traveling Grate with Undergrate Blast (*Ein Wanderrost mit Unterwind*, Pradel. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 35, no. 50, p. 535, December 13, 1912. 3 pp., 7 figs. *d*). The usual arrangement of traveling grates with undergrate blast is imperfect, according to the author, in that, unless the grate bars are very close together, small sized fuel cannot be used at all; in addition with the grate moving over a stationary air box in a fixed position and provided only with a few openings at the top, there is always a tendency for the ashes to gather at the top of the grate, and to hinder free access of air. The grate recently placed on the market by the Deutsche Unterschub-Feuerungs-Gesellschaft m.b.H., of Mannheim, Germany, is said to have obviated all these difficulties by the use, instead of a built-in air box, *of sectional air boxes* fed from the side, and formed from below by a special plate, and on the other sides by the grate plates and grate plate supports. There is therefore what amounts to a separate air box under each grate plate, fed with air from the side, and traveling with the grate; these air boxes are further arranged in such a manner that air is supplied only to those parts of the grate where combustion takes place; the beginning and end of the grate receive no air blast, and are strongly cooled, with a further possibility of regulating the cooling so as to suit various kinds of fuel. This grate is particularly adapted for *low priced fuel*, such as coke breeze, fine coal, etc.

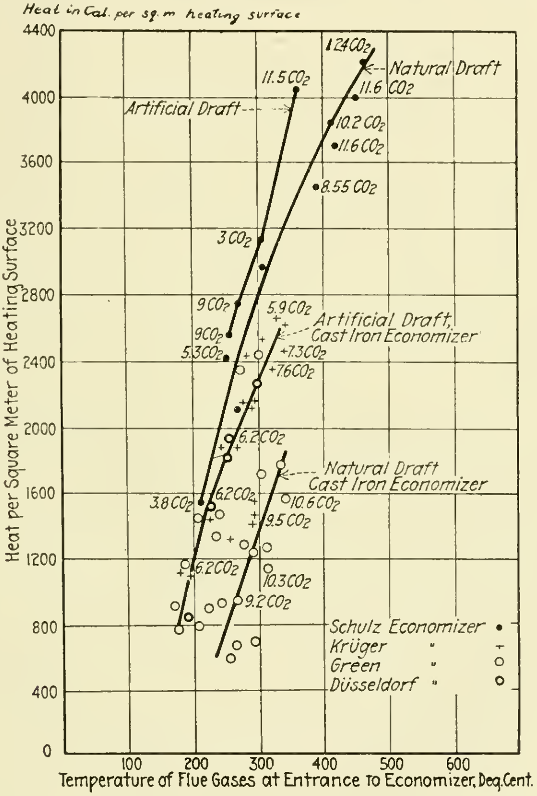

Fig. 5 Economizer Curves

Contribution to the Estimation of Smoke Damages in the Rhine-Westfalian Manufacturing District (*Beiträge zur Beurteilung von Rauchschäden im rheinisch-westfälischen Industriegebiet*, P. Kippert. *Glückauf*, vol. 48, nos. 49 and 50, pp. 1992 and 2026, December 7 and 14, 1912. 18 pp. *gs*). A comprehensive discussion of the smoke problem as applied to the Rhine-Westfalian manufacturing district. The important point this investigation brings out is that, as far as vegetation is concerned, it is not the solid particles of the smoke that are primarily injurious, but the gaseous, which may be by careful treatment made invisible enough to satisfy the smoke inspector, e. g. vapors of sulphuric acid from locomotives, hydrofluoric acid from brickmaking plants, etc. The author's own investigations have further shown that sometimes trees and plants are injured by the smoke and fumes although the amount of sulphuric acid present in the atmosphere appears to be insignificant; this is explained by the claim that only a small part of the H_2SO_3 emitted from the furnaces stays in the air, while its major part finds a way into the ground. Therefore in the neighborhood of industrial plants and manufacturing cities the ground is generally supersaturated with sulphuric acid which reaches it first in the form of sulphurous acid and is converted into sulphuric by oxidation with atmospheric oxygen. The harm of its presence lies in the fact that it converts calcium carbonate into calcium sulphate or gypsum, thus producing "delimation" (*Entkalkung*, decrease in the contents of calcium carbonate) which gives the ground an acid reaction and makes it unsatisfactory for plant growing purposes. This has been fully proved by the experiments of Wieler: a plot of ground on which all useful vegetation had been destroyed by the action of fumes from a silver smelting plant was cleaned of weeds and planted with pines; one part was left in its original state and the other fertilized by material rich in calcium carbonate. At the end of the third year the pines on the unfertilized plot died, while those on the fertilized developed normally. The article contains also other valuable data on the influence of smoke and fumes on plant growth, showing among other things that there may be cases where the presence of an excess of sulphurous acid in the air affects the plant growth favorably.

New Steam Boiler Constructions in Steam Turbine Plants (*Neuere Dampfkesselkonstruktionen für Dampfturbinenkraftwerke unter besonderer Berücksichtigung der Steilrohrkessel*, Fr. Münzinger. *Zeits. für das gesamte Turbinenwesen*, vol. 9, no. 34, p. 538, December 10, 1912. 4 pp., 11 figs. *d*). Continuation of a series of articles on new types of steam boiler construction, including the description of the *Ketzer boiler* made by H. Ketzer in Duisburg, Germany. The boiler proper is much like the Stirling boiler, with the difference, however, that the upper drums are connected by means of standpipes of large diameter. The superheater starts at the front-end plate and is arranged so that its coils pass through every second nest of the boiler tubes; as a result each row of water tubes is in proximity with a free nest of tubes, and the exchangeability of the water tubes is not affected. Should a superheater coil have to be removed, its free ends are pressed somewhat apart, whereupon it can be passed between the superheater steam collectors. An interesting type is also the Burkhardt boiler made by J. Piedboeuf in Düsseldorf, Germany (Fig. 6) in which one organic unit is made of the boiler and superheater as far as possible. Its four drums are connected in pairs by bundles of tubes having 51 mm (2.00 in.) external diameter; in these tubes the steam is generated, the water flowing back through larger tubes located along the outside shell of the boiler proper. The circulation of water follows therefore two independent but intersecting paths; in the upper boiler, above the ascending pipes, is placed a longitudinal plate to keep the circulation of water steady and to prevent violent variations of the water level. There are 7, 9 or 11 water tubes in one plane, their curvature being so proportioned that they may be removed when necessary through small holes in the jacket of the upper boiler; these holes serve also to clean the pipes without entering the boiler. The hot gases rise slowly in the high combustion chamber and transfer their heat mainly by radiation, while baffle plates made of refractory clay take care that all the tubes receive their due amount of heat. At the intersection of the nests an additional amount of heat is extracted from the gases by conduction owing to the strong formation of eddies. The gases then flow downwards, and, with a sharp change of direction, on to the two preheaters and smokestack. The two sharp changes of direction of flow of the gases help to shake out the ashes which settle down and can be conveniently removed through the dampers. The system of baffling the hot gases is interesting in that it is arranged so that the warmer gases are nearly always surrounded by layers of somewhat colder gases, thus materially decreasing radiation losses which are further decreased through the hottest gases being nearly always in immediate touch with the heating surfaces. The boiler shell is made of wrought-iron walls lined with fire clay and consisting almost entirely of flap doors; this increases the accessibility to the boiler and facilitates the cleaning of the economizer, an especially welcome feature as there are no mechanical appliances for this purpose. The preheater can be blown through by steam or compressed air even during the operation of the boiler, by means of nozzles rolled into the upper header. The superheater is placed inside the tube nests, and is in the same path of the hot gases as the water tubes, thus permitting a very strong superheating with a comparatively small surface of superheater, and the attainment of a high steam temperature at low loads. The hot gases flow through side openings in the brickwork shaft where the superheater is located, pass by it and come back to the boiler flues; rotary valves being provided to regulate the admission of the hot gases to the superheater coils. By a steam collector of generous size the steam is kept dry even with a strong demand on the heating surface. The article mentions tests made by Professor Langer and some organizations, but does not give any data.

Strength of Materials and Materials of Construction

TESTS FOR THE ELUCIDATION OF THE INFLUENCE OF THE STRESSES WHICH ARE PRODUCED IN THE MATERIAL BY RIVETING AND MAY LEAD TO THE SPLITTING OF RIVET HOLES (*Versuche zur Klarstellung des Einflusses der Spannungen, welche durch das Nieten im Material hervorgerufen werden und die der Entstehung von Nietlochrissen Vorschub leisten können*, C. Bach and R. Baumann. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 47, p. 1890, November 23, 1912. 6 pp., 14 figs. *cA*). The tests were made at the Laboratory for Testing Materials of the Technical High School at Stuttgart, Germany. Owing to lack of space only the final conclusions of this important investigation can be given here:

(*a*) The tests have shown that owing to the application of the usually large powers in *riveting machines* the sheets in the neighborhood of the riveting holes are subjected to stresses beyond the elastic limit. (*b*) With sheets adhering closely to each other, the pressure exerted by the riveting machine has no influence on the force with which the rivets after cooling hold the sheets together; the contraction in the shank of the rivet alone is quite sufficient for the production of a large stress in the shank and a sufficient resistance to sliding in the rivet connection. The *magnitude of useful pressure required in riveting* appears therefore to be determined

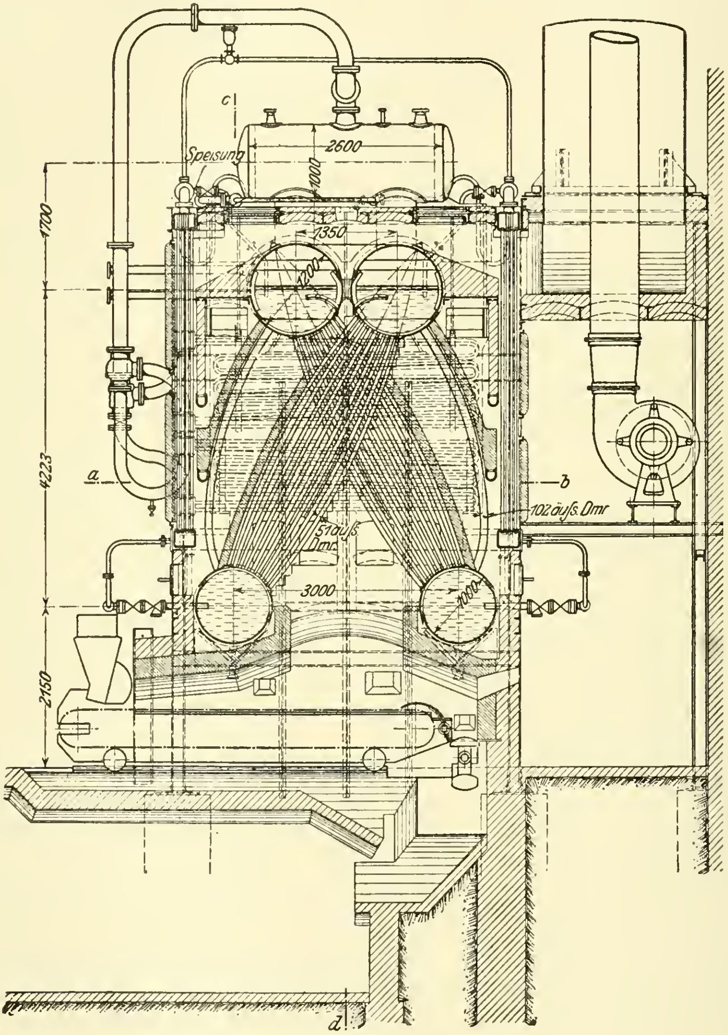

Fig. 6 Burkhardt Water Tube Boiler

only by the following: (1) the necessity of making well formed, caulkable rivet heads, and (2) the necessity of keeping together sheets which would otherwise have a tendency to yawn. (*c*) When a larger pressure is applied than that warranted by (*a*), the sheets are stressed beyond the elastic limit, and the riveted connection is actually made weaker than it would be with smaller pressure. The use of excessive forces in riveting explains the frequent occurrence of bending of sheets at the riveted joint and pressing-in of rivet heads in steam boilers which is due to crushing of the plate under the rivet head while riveting. (*d*) The length of time during which the riveting pressure is exerted is of importance only when the sheets have a tendency to spread, and even then the tests have shown that the application of a pressure during 1 minute is quite sufficient. (*e*) *Short rivets appear to be weaker than long ones*, a consequence of the change of shape in and under the rivet head. For lengths longer than $l = 3d$ no further increase in strength was found. The maximum observed stress approaches the lower elastic limit of the material. (*f*) When long rivets are partly warmed-up, there is a danger of the swage-heads breaking off and the material being permanently injured; this may be prevented by a fillet at the place where the shank connects with the rivet head. Several photographs of split rivet holes, rivets broken off at the swage-head, etc., are reproduced in the original article.

EXPERIMENTS ON THE DISTRIBUTION OF STRESSES IN PUNCHED FLAT BARS (*Versuche über die Spannungsverteilung in gelochten Zugstäben*, E. Preuss. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 44, p. 1780, November 2, 1912, 3 pp., 6 figs. *c, and Mitteilungen über Forschungsarbeiten*, Heft 126, p. 47). The author made his tests with flat bars having a rectangular cross-section, and provided, across their middle axis, with a hole of diameter D (Fig. 7); the bars were subjected to a tension P along the longitudinal axis. Let the section of the remaining metal at *A-C* be called f. It is usual to design bars of this kind, as far as their safe strength is concerned, by determining the average stress $\frac{P}{f}$ in the section *A-C*, and then selecting P in such a manner that $\frac{P}{f}$ be well within the safe limits for the given material. It is here assumed, however, that the distribution of stresses in that cross-section is uniform throughout, and this is approximately true at the moment of rupture. But up to the elastic limit, or within the useful range of stresses, the stresses are not uniformly distributed: on the contrary, there is a considerably higher stress at the edges of the hole, and a much lower stress at the outer edges of the bar, approximately as shown by *E-R* in Fig. 7. The author shows also that: (*a*) the maximum stress at the edges of the hole is not materially affected by the magnitude of the diameter of the hole; (*b*) the maximum stress at the edge of the hole is 2.1 to 2.3 times greater than the value obtained for it on the supposition of uniform distribution of stresses through the section most weakened by the punching of the hole; (*c*) the minimum stress at the outer edge of the bar decreases as the diameter of the hole increases.

INVESTIGATION OF THE DIRECTION OF STRESS IN INCLINED PLATES (*Untersuchungen über die Kraftrichtung in schiefen Platten*, C. Busemann. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 47, p. 1907, November 23, 1912, 4 pp., 9 figs. *dc*). Description and data of tests on the direction of stresses in inclined plates. By inclined plates are here meant plates with bearings parallel to one another, but at an oblique angle to the longitudinal axis of the opening, so that in the horizontal projection the plate appears as shown in Fig. 8A. Textbooks as a rule state that the stresses are distributed on both sides of the line *A-B*, or equally on both bearings, but the author by several methods, mathematically and experimentally, shows that in the case of inclined plates with two bearings the resultant of stresses lies not in the middle between the bearings, but more towards the obtuse angles, as shown by the line *A'-B'*, in Fig. 8B. The methods for the determination of the position of the resultant are given, both for a single load in the middle and for a uniformly distributed load, and it is shown that if an inclined arch is subjected to an effort tending to shorten its arc, the resultant is shifted towards the obtuse angles, and towards the acute angles when the efforts tend to lengthen the arc. The first happens when the moment is positive (pressure above, tension below), the second when the moment is negative (tension above, pressure below), and may be due to changes of load, variations in temperature, etc. This article may be of particular interest to the designer of inclined reinforced concrete plates in showing how the reinforcing elements may be distributed to take care of the stresses arising in the various parts of the structure.

ON AN EXPERIMENTAL METHOD FOR DETERMINING IN ADVANCE THE STRESSES WHICH WILL ARISE IN STRUCTURES (*Sur une méthode expérimentale pour déterminer à l'avance les tensions qui se produiront dans les constructions*, Mesnager. *Comptes Rendus des séances de l'Académie des Sciences*, vol. 155, no. 22, p. 1071, November 25, 1912. 2 pp. *eA*). If a sheet of glass is subjected to strains situated in its plane, and if at each of its points is projected, normal to its plane, a ray of polarized light, then: (*a*) it transmits two vibrations parallel to the principal stresses, thus permitting the determination of their direction; (*b*) the difference of the course of the two vibrations makes it possible to determine the difference between the two principal stresses, by the Werthein method; (*c*) the variation in thickness shows the sum of these stresses (for the general description of this method see A. Mesnager, *Utilization of the Accidental Double Refraction of Glass for the Study of Internal Stresses in Solids*, in Transactions of the Sixth Congress of the International Association for Testing Materials, XXVIII, 5, No. 11).

On the other hand it is known that elastic stresses in two dimensions depend on the differential equation

$$\Delta\ (n_x+n_y)=0,\ \Delta=\frac{\partial^2}{\partial_x^2}+\frac{\partial^2}{dy^2}$$

containing only coefficients of elasticity. Therefore, if the conditions at the limits do not depend on the coefficients of elasticity, the solution of the equation is entirely independent of them, and the distribution of stresses in the glass is fully identical with that in any other material. Hitherto this process has been applied only to the investigation of stresses in objects of simple shape, owing to the high cost and difficulty of making suitable complicated models and to the fact that in such models even careful annealing does not entirely remove the internal stresses produced in making the piece; the same is true for composite pieces formed by welding. The author has, however, obtained excellent results by gluing together pieces of glass cut from carefully annealed sheets using as an adhesive gelatine made soluble at room temperature. It is quite transparent and does not hinder observation, giving at the same time, when dry, a tangential adherence of 0.5 kg/qmm (711 lb. per sq. in.) which is sufficient for all general purposes. The model is constructed while in a horizontal position, and is left so until completely dry: in this way internal stresses are nearly entirely eliminated.

The author has investigated by this method a project of a bridge 97 m (320 ft.) span by making a model 0.003 to 1, and by reducing the section to rectangles by means of appropriate formulae of mechanical similarity, and succeeded in determining: (*a*) the points of maximum stresses; (*b*) the most unfavorable combinations of loads; (*c*) the magnitude of maximum stresses, tensile and compressive. Check values obtained by the additions of the stresses produced by the action of separate loads on one hand, and by the direct application of the most unfavorable total load, differed by less than 1 per cent from the values of the maximum tensile or compressive stresses. The cost of the model amounted to less than 1/10 of 1 per cent of the work. Cp. also *Engineering Record*, no. 2, 1913, January 11, p. 30, *Optical Determination of Stresses*, where similar experiments with models made of celluloid compounds are described.

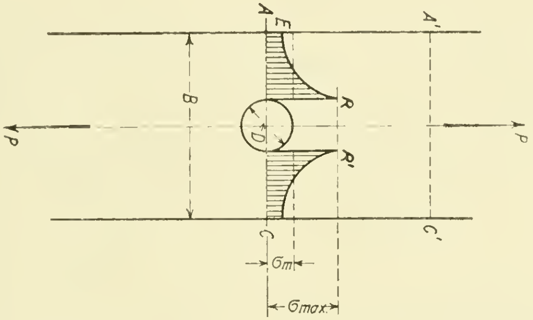

Fig. 7 Distribution of Stresses in Punched Flat Bars

Hydraulic Lime (*Hydraulischer Kalk*, G. Hentschel. *Tonindustrie-Zeitung*, vol. 36, no. 139, p. 1843, November 23, 1912. 1 p. *pt*). The usual equation for the determination of the *hydraulic modulus* of hydraulic lime is $\frac{CaO + MgO}{SiO_2 + R_2O_3}$, but this equation gives only the theoretical modulus, and does not take account of the free silicic acid, clay and unburned calcium carbonate which affect the properties of hydraulic lime. Table 2 column I gives the actual figures as obtained by analysis, II is the chemical composition of the same material burned and free from water and carbon dioxide, III is the corrected analysis taking care of the loss in burning, while IV is the same as III, but reduced to water-free material. It is seen from these analyses that while the theoretical hydraulic modulus is

$$M_t = \frac{CaO + MgO}{SiO_2 + R_2O_3} = \frac{75.51}{24.13} = 3.13$$

the actual hydraulic modulus is

$$M = \frac{58.13}{15.77} = 3.68,$$

an important difference considering the value of hydraulic lime is the higher the nearer its hydraulic modulus approaches that of portland cement. The author recommends therefore that not only the theoretical modulus be indicated, but the actual modulus and percentage of nonmortar materials as well (insoluble matter and calcium carbonate).

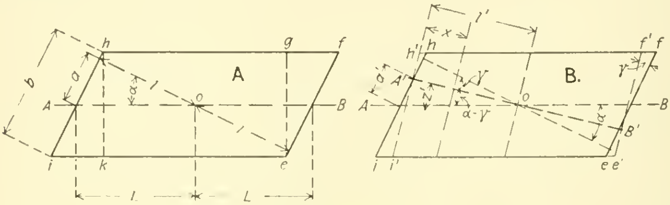

FIG. 8 DIRECTION OF STRESS IN INCLINED PLATES

TABLE 2 PERCENTAGE ANALYSES OF HYDRAULIC LIME

	I.	II.	III.	IV.
SiO_2	14.0	16.89	8.30	9.15
Al_2O_3	6.0	7.24	6.00	6.62
Fe_2O_3				
CaO	62.1	74.91	52.20	57.58
MgO	0.5	0.60	0.50	0.55
SO_3	0.2	0.24	0.20	0.22
Loss in burning	17.1	...	...	...
Not determined	0.1	0.12	0.10	0.11
$CaCO_3$	...	...	17.66	19.48
Insoluble matter	...	...	5.70	6.29
Water	...	...	9.34	...

The author made experiments with addition of gypsum to hydraulic lime and found that it affects favorably the tensile and compressive strength of lime, and does not involve any particular difficulties as it does not affect the setting time of lime.

CHRISTIANIA LABORATORY FOR TESTING MATERIALS (*Kristiania MaterialprΦveanstalt, Teknisk Ukeblad*, vol. 59, no. 51, p. 653, December 20, 1912. 4 pp., 5 figs. *d*). Description of the recently opened laboratory for testing materials in Christiania, Norway (Director Engineer Wazau).

ON SELF-STRESSES AND DERANGEMENTS IN MACHINE PARTS THEREBY PRODUCED (*Über Eigenspannungen, insbesondere Reckspannungen, und die dadurch bedingten Krankheitserscheinungen in Konstruktionsteilen. Zeits. für präktischen Maschinenbau*, vol. 3, no. 48, p. 1618, November 27, 1912. *etA*). Account of a paper presented by Prof. E. Heyn, of the Royal Laboratory for Testing Materials of Gross Lichterfelde West, at the 14th annual meeting of the German Society of Naval Construction, in which he traced the cause of some hitherto unexplained breakdowns of steam turbine blades and other machine parts to what he calls *self-stresses* (*Eigenspannungen*); such stresses arise when in a machine element certain parts rigidly connected together are submitted to different stresses and have, owing to the rigidity of connection, to equalize them by elastic changes of form. Such stresses may arise both through unequal heating and cooling, or by permanent changes of shape at ordinary temperature, such as cold rolling, cold hammering, etc. Professor Heyn has worked out a process for determining the magnitude of such stresses, and a series of tests have been made at the Royal Testing Laboratory, at Gross Lichterfelde West which have given an insight into the nature of these stresses; finally means have been devised for obviating their appearance in metal parts when subjected to cold working. He showed further that there is a large number of undesirable structural modifications in metals which apparently have no connection with one another, but can in the final analysis be traced to self-stresses; to this group belong ruptures of steam turbine blades made of high percentage nickel steel, fractures in rods, wires, plates and tubes made of brass, bronze, aluminum bronze, etc.; breakdowns of the above parts, owing to temperature variations and mechanical injuries, as well as to the action of certain paints, and influence of working at a blue heat (150 to 350 deg. cent., or 302 to 662 deg. fahr.) on iron, etc.

A more complete account of this paper will be given in The Journal when the full text of the original paper is received in this country.

Thermodynamics

The Modern Development of Thermodynamics (*Zur neueren Entwicklung der Thermodynamik*, H. Sieveking. *Journal für Gasbeleuchtung*, vol. 55, no. 48, p. 1174, November 30, 1912. 3 pp. *t*). A discussion of the latest achievements of thermodynamics, mainly on the basis of a paper read by Professor Nernst before the Munster meeting of the German Scientists and Physicians. The two most important things that were unknown to the founders of the science of thermodynamics are radioactivity and the measurement of energy contents or specific heats of substances. The author, or rather Professor Nernst, holds that in accordance with the second law of thermodynamics the amount of that energy in the world which is convertible into work is becoming more and more dissipated (Cp. Chas. P. Steinmetz, The Second Law of Thermodynamics and the "Death" of Energy, General Electric Review, July 1912, vol. 15, no. 7, p. 419) since, as soon as heat has flown to a lower temperature level, its convertibility into work is no more possible; in addition, the matter itself is being "degraded" owing to the action of radioactive forces, gradually changing nobler metals into baser. The only way in which these tendencies may be counteracted is by some reconstruction process of the elements themselves, but it does not appear that such processes do actually take place, at least not within the limits of time accessible for experimentation and observation.

A brief discussion of the Planck theory of quanta, and some of the developments based on it, follows, as well as brief statements of the work of Haber and Just on the relation between the reaction heat of the chemical processes and the electronic frequency as determined by the selective photoelectric effect. The bearing of the Einstein formula on the law of Dulong and Petit is also discussed. The article is of considerable interest in that it gives the latest data on the development of the theory of thermodynamics with only a very sparing use of mathematical formulæ or terms.

RELATION BETWEEN THEORY AND EXPERIENCE IN THE DOCTRINE OF HEAT TRANSMISSION (*Beziehungen zwischen Theorie und Erfahrung in der Lehre vom Wärmeübergang*, H. Gröber. *Gesundheits-Ingenieur*, vol. 35, no. 50, p. 929, December 14, 1912. 7 pp, 2 figs. *mtA*). Mathematical investigation of the theory of heat transmission, mainly as applied to the case of fluids flowing through pipes. The author applies the so-called *principle of similarity*. The essential elements of this method consists in the following: a comparison is made between two or more systems (e.g. flow with local temperature inequality) similar to one another in a certain particular. This similarity is mathematically established by the requirement that the respective processes in both systems should satisfy the same differential equations, the latter therefore to be solved in the same manner. The processes within each group of the similar systems occur then in the same way, and the number of independent variables to be established experimentally in determining the functional relations is correspondingly reduced. The author proceeds to show how the *similarity characteristic* is determined, and how this method is applied to the investigation of the problem of heat transmission in the case of fluids flowing through pipes. He derives a general formula for the coefficient of heat transmission in the case of flow through pipes, but points out the following deficiencies in the methods of treating this problem: (*a*) lack of knowledge as to the laws governing the relation between the coefficient of heat transmission and the length of the pipe in the case of turbulent flow (flow accompanied by the production of eddies); (*b*) lack of uniformity in the determination of relative roughness of pipes; (*c*) lack of exact data as to the viscosity and heat conductivity of gases and especially of liquids, as well as their variation with temperature. The article treats the principle of similarity in comparatively easy mathematical methods (only very simple partial differentials are used) and in a very clear style. A short bibliography is appended.

Miscellanea

TRACTORS: AVERAGE AND MAXIMUM TRACTIVE CAPACITY (*Tracteurs agricoles: traction moyenne et traction maximum*, Max Ringelmann. *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, vol. 118, no. 3, p. 448, November 1912. 7 pp., 7 figs. *e*). The author claims that many failures of farm tractors were due to designers often equipping them with power sufficient only to provide *average* efforts at the drawbar. He made a series of tests with nine tractors of French design, and found that, on various grounds, the maximum effort T varied from $110.55t$ to $154.70t$, where $100t$ was the average effort, and the stretch over which this maximum effort was exerted varied from 2 to 27 per cent of the total run of the tractor. The author recommends therefore that the engine be proportioned so that it could deliver when called upon, an effort

$$T = 175\,t$$

The weight of the tractor must be such that there should be adherence enough between the ground and the driving wheels of the machine to prevent slipping at the maximum driving resistance. Tabular data and diagrams of efforts are given in the original article.

CONSTITUENT GENERAL MEETING OF THE SOCIETY "TECHNICAL MUSEUM OF INDUSTRIES AND TRADES IN VIENNA" (*Konstituierende Generalversammlung des Vereines "Technisches Museum für Industrie und Gewerbe in Wien." Zeits. des Oesterreichschen Ingenieur und Architekten-Vereines*, vol. 64, no. 49, p. 777, December 6, 1912. 1 p. *g.*). Reportorial account of the first meeting of the Society for the Establishment of a Technical Museum of Industries and Trades in Vienna. No details as to the program and scope of the Museum are given. For the latter see *Scientific American*, January 11, 1913.

Supplementary References

BENDING OF CAST IRON BARS (Foreign Review, June 1912 p. 971). The full text of the original investigation published in *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, Heft 127 and 128, 101 pp., 55 figs.

EXPERIMENTS ON REDUCTION OF STRESS BY ROUNDING OFF SHARP ANGLES (Foreign Review, November 1912, p. 1897). The full text of the original investigation published in *Mitteilungen über Forschungsarbeiten*, Heft 126, 24 pp., 27 figs.

DISTRIBUTION OF STRAIN IN CRANE HOOKS (Foreign Review, March 1912, p. 409). The full text of the original investigation published in *Mitteilungen über Forschungsarbeiten*, Heft 126, 22 pp. 27 figs. The investigation is interesting in that it shows the unreliability of theoretical calculation of stresses in crane hooks, stresses so determined being sometimes greater, at other times considerably smaller than those actually occurring.

SCHOOP PROCESS OF GALVANIZING (Foreign Review, March 1912, p. 418). Description of the process as it is now used and improved apparatus in *Zeitschrift für Sauerstoff- und Stickstoff*, vol. 4, no. 12, p. 245, December 1912.

ARTICLES UPON GAS POWER

(Prepared by the Literature Committee)[1]

DIESEL ENGINE USERS, SOME PRACTICAL CONSIDERATIONS FOR. *The Engineer* (London), December 6, 1912. 2 columns. *pA*.

Its suitability for many kinds of crafts, etc.

MOTOR CAR SHOW AT OLYMPIA. II. *The Engineer* (London), November 15, 1912. 2 pp., 7 figs. *dpC*.

Description of various motors for cars.

MOTOR SHIP JUNO, THE. *The Engineer* (London), November 15, 1912. 3 figs. *C*.

Description of ship and engines.

MOTOR VEHICLES, THE DESIGN OF, H. E. Wimperis. *The Engineer* (London), November 15, 1912. 2 pp., 3 figs. *dmpA*.

Size of engines and gear ratios, break m.e.p. independent of stroke and bore, tractive effort and complete design of motor.

PEAT FUEL IN GAS PRODUCERS AND THE ELIMINATION OF TAR FROM PRODUCER GAS, CANADIAN STUDIES OF, B. F. Haanel. *Engineering News*, December 5, 1912. 8 figs., 3 tables.

PETROLEUM AS A SOURCE OF POWER FOR SHIPS, Albert Sommer. *The Journal American Society of Naval Engineers*, November 1912. 27 pp., 7 tables.

PRODUCER GAS IN SOUTH STAFFORDSHIRE, THE GENERATION AND DISTRIBUTION OF, H. A. Humphrey.

Extract of paper read at meeting of Institution of Civil Engineers, December 10, 1912.

MOTOR SHIP ROLANDSECK. *The Engineer* (London), December 15, 1912. 1 column and supplement, 4 figs. *dpB*.

Description of the Carels-Tecklenborg engines.

SMITHFIELD CLUB SHOW, THE. *The Engineer* (London), December 19, 1912. 3 pp., 5 figs. *C*.

Description of Peter's semi-Diesel engine; Davy Paxman's gas engine; Ruston Proctor's oil engine, etc.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

REPORTS OF MEETINGS

MEETINGS IN CHICAGO

At a meeting of the Chicago Section in that city on November 21, 1912, P. M. Chamberlain, Chairman of the Committee on Meetings in Chicago presided. The affairs of the Section were turned over to the new committee by the retiring chairman, George M. Brill. Addresses were made on behalf of the Society by W. F. M. Goss, for the Western Society of Engineers by W. L. Abbott, for the American Institute of Mining Engineers by Capt. Robert W. Hunt, and for the American Institute of Electrical Engineers by Peter Junkersfield. P. W. Gates also spoke. This meeting was held at the Chicago Engineers Club, with about 60 in attendance.

On December 19, 1912, a meeting was held in the rooms of the Western Society of Engineers, with Engineering in Panama and South America as the subject of the evening, Col. Henry A. Allen speaking upon the Association of Commerce, upon the achievements in South America. An work in Panama and F. C. Enright, South American representative of the informal discussion followed. About 60 engineers attended this meeting.

ST. LOUIS MEETING, DECEMBER 14

The Local Section of the Society in St. Louis held its annual meeting on December 14, at the Mercantile Club, the meeting being preceded by an informal dinner. The following members were elected to serve on the local committee: E. H. Ohle (five years), F. E. Bausch (four years), John Hunter (three years), L. C. Nordmeyer (two years), and F. N. Jewett (one year), Professor Ohle serving as chairman, and Mr. Bausch as secretary.

A general discussion followed on engineering subjects of present-day interest. The local committee, together with J. H. Boughton, was requested to draft a report on the desirability and benefits of installing water meters for all consumers of city water.

NEW YORK MEETING, JANUARY 14

At this first meeting of the year, the plan adopted last year was followed of discussing matters identified with the work of the New York Committee. Following this discussion, a brief paper was presented by F. A. Waldron on Factors of Scientific Management other than Labor Problems. This paper is in substance the discussion offered by Mr. Waldron upon the report of the sub-committee on Administration, given at the Annual Meeting, and will be referred to more at length in a later issue.

For the purpose of keeping the New York membership in touch with what the local committee has done, a communication from the retiring chairman, Fred. H. Colvin was read, summarizing the meetings for the past year, and outlining his views upon the question of ways and means for providing for the entertainment at the time of the Annual Meeting, already much-discussed. In accordance with a vote of the committee a year ago, the recent Annual Meeting had been conducted on the "pay as you go" plan. The circular announcing this plan was sent to the membership along with several other circulars on different subects, and undoubtedly was overlooked by many members who came to the meeting without a knowledge of the new plans. He advocated another trial of the plan to form a fairer basis of comparison with the previous system of soliciting subscriptions locally.

Following this, the discussion was opened, upon request of the chairman, by R. V. Wright for the "pay as you go" plan and by Edward Van Winkle for the subscription plan. Mr. Wright said that the canvass of the New York membership last year showed the sentiment to be in favor of a $3 annual assessment on the New York members, but this had not been approved by the Council and the committee therefore made a trial of having every member pay for such entertainment as he participated in, with the exception of the President's Reception, which was paid for out of the Society funds. This was in line with what many other societies are doing, notably the Master Car Builders Association and the American Railway Master Mechanics Association. There are many young men in the New York membership who want to enjoy the privileges of the Society but cannot afford the usual contribution heretofore called for, and they are likely to remain away from professional as well as social meetings on this account.

Mr. Van Winkle confined his remarks mainly to attendance figures at the Annual Meetings of the past three years, showing an increase in 1911 over 1910, but a decrease in 1912, although there had been a large increase in membership. At the luncheons those participating in 1912 were fewer in number also and at the second day of the luncheon there was a marked decrease. The main object of luncheons is to promote sociability and to keep the members together so as to increase the attendance at professional sessions. Failing in that, why not abandon Society luncheons? Under the subscription plan while the payments came on the average from only about one-third of the local membership, it was not the same 300 who contributed every year. The average was $10 per subscriber, but amounts as small as $1 were received and there were many cases where it was arranged that members should receive tickets to the Thursday night reunion even though they did not contribute the actual value of the ticket. The subscription plan is necessary to create an air of hospitality.

Messrs. Wright and H. R. Cobleigh contended that the figures quoted had no significance, and the decrease in attendance at the second day's luncheon last December was attributed to disatisfaction with the service. Simultaneous sessions were held throughout the convention, making it difficult to attend the luncheons in some cases. At the Railroad Session were many who came for that meeting only and undoubtedly did not register; and they were unable to attend the luncheon as the interest in the meeting was so great that it did not adjourn until 1.30.

Fred. J. Miller had for a long time advocated an increase in the dues of local members. The expense to them would be no greater than that of an out-of-town member who came only occasionally to a convention and had transportation and hotel expenses to pay. However, the "pay as you go" plan had its advantages. He believed that most of the falling off at luncheons was due to the New York members taking lunch elsewhere, as he had met mainly out-of-town people during the lunch hour in the Engineering Societies Building.

Several outlined the successful and apparently unobjectionable means that had been adopted in other cities for the Spring Meetings for the entertainment of guests. Jesse M. Smith who formerly lived in Detroit said that when there were only twenty members in that city not only was there no difficulty experienced in raising funds for the entertainment of the Society but that it was a pleasure to do this and that $200 above the expenses was turned over to the library of the Society. William Kent was reminded of the trip to Europe in 1889 when free transportation was provided between Liverpool, London and Paris, and so large a sum was raised that a dividend was returned to subscribers. This experience was repeated in a measure in this country when the British Iron & Steel Institute and the Verein deutscher Ingenieure came here. Reference was made also to the Richmond meeting which was so successful, where the experience had been similar to that of Detroit; and by another member to a more recent meeting where it was believed that the subscription plan had been found burdensome although the members locally were not disposed to admit that such was the case.

This led to the question of approaching manufacturers for subscriptions, which while generally practised in the smaller cities, was not attempted in New York and it was believed would be considered unprofessional to do so under the conditions which here exist.

Various other speakers expressed their preference for or against the "pay as you go" plan, and Mr. Cobleigh emphasized that members in out-of-town places would not feel that they could take the initiative in introducing the "pay as you go" system, even though they might find subscriptions burdensome, until New York had introduced this as a policy for the conduct of the Annual Meetings.

The attendance at this meeting was small, but as a test of the sentiment of those present, a rising vote was taken, showing 33 in favor of reverting to the subscription method, and 17 in favor of the "pay as you go" plan.

BOSTON MEETING, JANUARY 22

The members of the Society and the Boston Section of the American Institute of Electrical Engineers joined the Boston Society of Civil Engineers at a meeting held in Chipman Hall on January 22, 1913. William H. Lewis, president of the Lewis Wiley Hydraulic Company of Seattle, Washington and Portland, Oregon, gave a talk on Hydraulics in City Building, copiously illustrated with lantern slides. Mr. Lewis described the work done by his Company at Denny Hill and Jackson Street Hill, Seattle, where the prevailing grades of 15 to 20 per cent were reduced to from 3 to 5 per cent and the material taken out used to fill tide lands on the water front constituting the terminals of the Great Northern, Northern Pacific and Union Pacific Roads. The slides showed very clearly the manner in which the material was taken out by hydraulic "Giants" conveyed by sluices and pipe lines to the fills and in many cases buildings and streets were raised and supported on temporary trestles while filling was done under them. He also explained how the blue clay which in a bank would resist the action of a hydraulic jet almost indefinitely, was loosened by shooting it with dynamite at the bottom of the bank so that a matter of a few hours sufficed to crumble it into a consistency that could be floated away. Later on he described the work of his Company at Portland, Oregon, where the matter handled was predominantly gravel. A very interesting detail was the method of applying the renewable linings to the bottom of the sluices and pipes. The character and extent of the pumping plant which comprised electrically driven centrifugal pumps of great capacity was strikingly shown.

In the discussion some very interesting points were brought out by the large number of questions which were asked during and at the close of the talk.

STUDENT BRANCH MEETINGS

ARMOUR INSTITUTE OF TECHNOLOGY

On January 15, 1913, the Armour Institute of Technology Student Branch was addressed by C. W. Taylor, who spoke on the Power Plant of Marshall Field & Company. The lecture was of particular value because of the speaker's personal experience at the plant in the capacity of operating engineer. A general discussion followed in which Professor Gebhardt, O. Schmeiman, M. D. Wold, E. R. Burley and H. R. Kuehn took part.

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch on January 9, 1913, two papers were presented, Gas Engine Design, by M. H. C. Brombacher, and Furnaces and their Construction, by Mr. Rittman.

LEHIGH UNIVERSITY

A meeting of the Mechanical Engineering Society of Lehigh University was held January 14, at which Mr. Rosenschweig of the Erie City Iron Works spoke on The Application of the Lentz System of Superheat to Different Types of Prime Movers. The lecture was illustrated with lantern slides showing the application of the Lentz system to stationary marine and locomotive engines, the construction and manner of operation of the poppet valves and the governing apparatus. Statistics were given showing the efficiency and economy of the Lentz system.

LELAND STANFORD JUNIOR UNIVERSITY

The Student Branch at Leland Stanford Junior University has been active during the past semester. On October 8, Prof. W. F. Durand gave an address on the Diesel Engine and its Growing Importance Commercially, and at a meeting held on October 22 papers were presented by C. S. Simon on Alloy Steel, and by K. I. Marshall, on High-Speed Steel. On November 25, Prof. Guido H. Marx gave an illustrated talk explaining his experimental derivation of new constants for the Lewis gear formula.

It is expected to have a number of scheduled addresses during the Spring semester.

POLYTECHNIC INSTITUTE OF BROOKLYN

At a meeting on January 4, Mr. S. Rosenzweig of the Erie City Iron Works lectured on the Lentz Engine, with discussion by Prof. W. D. Ennis, Prof. A. A. Adler, and Messrs. Greer, Heustis and Kessler, and many of the members.

STEVENS INSTITUTE

The Stevens Engineering Society held a meeting on January 7 at which Calvert Townley, assistant to the President, Westinghouse Electric and Manufacturing Company, spoke on the Electrification of the New York, New Haven and Hartford Railroad, the largest examples of steam railroad electrification in the world. Prof. A. F. Ganz and J. H. Vander Veer discussed the subject at the conclusion of the address.

R. V. Norris, Mem.Am.Soc.M.E., consulting engineer for the coal companies of the P.R.R. Co., D.L.&W.R.R. Co., the Wilkes-Barre and Hazelton R.R. Co., and the Sterling Salt Co., and who is a lecturer on Coal Mining at Harvard University, gave an address on Mechanical Preparation of Anthracite, on January 21. On February 11, Rudolph Hering, Mem.Am.Soc.M.E., will speak on Sewage Disposal, on which he is an authority.

SYRACUSE UNIVERSITY

At a meeting of the Syracuse University branch on December 12, S. Rosenzweig of the Erie City Iron Works delivered an instructive talk on the Lentz Engine, illustrated by lantern slides. On December 19, Prof. John E. Sweet, Hon.Mem.Am.Soc.M.E., gave a brief history of the steam engine, in which were included some interesting personal reminiscences.

UNIVERSITY OF ILLINOIS

The University of Illinois Student Branch held its regular meeting on January 17, electing the following officers for the semester: C. A. Schoessel, president, A. M. Simpson, vice-president, E. M. McCormick, secretary, and Geo. M. Meyer, treasurer. A talk on The Properties of Saturated and Superheated Ammonia was given by W. E. Mosher.

UNIVERSITY OF MISSOURI

On January 6 J. W. Haney and R. Runge presented a paper on Agricultural Machinery, illustrated by lantern views of farm scenes and implements used.

UNIVERSITY OF NEBRASKA

At a meeting on January 7, the Uses of the Tractor was presented by E. R. Wiggins and discussed by Prof. L. W. Chase and Prof. J. D. Hoffman.

YALE UNIVERSITY

An illustrated lecture on the Use of Superheated Steam and the Lentz Engine was delivered by S. Rosenzweig of the Erie City Iron Works, at the meeting of the Yale Mechanical Engineers Club, on January 7. A general discussion followed.

NECROLOGY

ELMER S. FARWELL

Elmer S. Farwell who died in Kansas City, Mo., on December 13, 1912, was born December 20, 1863, at Morrison, Ill. He received his education at the Baldwin University, Baldwin, Kan., and later at the Rensselaer Polytechnic Institute, Troy, N. Y., being graduated in the class of 1891. For a time he was in the employ of the Illinois Steel Company at South Chicago, going from there to the Patent Office at Washington, where he was assistant examiner in the Division of Steam Engineering. During this period he was also an instructor in the department of steam engineering of Columbian University, Washington, D. C. In 1898 he came to New York to take up work with the International Paper Company, but later retired from their employ to open an office for himself as consulting engineer. In this capacity he was retained by the Yellow Pine Paper Mill Company to install their evaporator system and later to rebuild their plant. In the fall of 1911 he moved to Kansas City, where he continued his consulting practice until shortly before his death.

ERWIN GRAVES

Erwin Graves was born near Tiffin, Ohio, August 19, 1850, and was educated in the public schools. At the outset of his career he was for several years surveyor for railroads. He then entered the employ of J. D. Cook of Toledo, Ohio, where he assisted in the building of the Sandusky Water Works. During his four years' residence in Sandusky he was superintendent of water works and city engineer. From Sandusky Mr. Graves went to Quincy, Ill., where he built the water works, later going to Atlantic City, N. J., in the employ of R. D. Wood & Company, for the same purpose. In 1885 he became connected with the Camden Iron Works, Camden, N. J., and was until 1890 assistant superintendent. In 1894 he returned to the works as superintendent, a position which he held at the time of his death on December 13, 1912.

Mr. Graves was a member of the Engineers Club of Philadelphia for many years, but resigned from it before his death.

HARRY M. ROSE

Harry M. Rose was born at Albany, N. Y., November 22, 1856, and died at Elizabeth, N. J., December 25, 1912. He received his education in private schools and under private tutors, and afterwards entered the service of the F. O. Matthiessen and Wiechers Sugar Refinery, with a view to learning the business. Upon completion of a four years' course he went to San Domingo and there engaged in sugar harvest work. Following this he went to the Philippine Islands for the George L. Squier Manufacturing Company of Buffalo, N. Y., and was engaged in that country for a period of three years in installing the machinery on sugar and rice plantations. Upon his return from the Philippines he made a number of trips to Mexico and Central America as constructing and consulting engineer in the line of plantation machinery.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The list of "men available" is made up from members of the Society and good men not members. Information will be sent upon application.

POSITIONS AVAILABLE

018 Assistant to manager of factory, preferably technical graduate with engineering training, but of prime importance that applicant have actual experience in directing production of merchandise. Location, Connecticut.

019 Technical graduate with three to five years' experience in electrical or gas apparatus testing work, for development and acceptance tests with installation work of new line of high grade apparatus. The right man will have an opportunity for valuable experience and opportunity for advancement to a responsible position in a growing manufacturing and selling organization in the Middle West.

020 Young engineer for metallurgical plant, technical education with several years' mechanical engineering experience and possessing fair working knowledge of chemistry and electrical engineering; to take care of plant engineering work, conduct miscellaneous investigations and institute improvements; should be resourceful and energetic. Location, Middle West.

021 A new steam turbine of the compound impulse, multi-stage type, capable of good efficiency in all sizes from 1 h.p. upward, is ready for commercial development. A high-grade successful salesman of steam turbines, who can furnish necessary capital, is desired as a partner to assist in development of the project. Reply through the Society.

022 Young engineer for time and operation study and to start in on efficiency work under superintendent. Location, Connecticut.

023 Mechanical draftsman with one to two years' experience for tracing and detail work. Salary according to experience. Location, New York.

024 Man with experience in steam work, particularly along power lines, and if possible familiar with heating and ventilating work, who would be interested in partnership with firm of consulting engineers in Boston. Particularly desire man of good address who would be willing and able to spend the larger portion of time looking after and supervising new work in field, or office. Apply through the Society.

025 Mechanical draftsman on mill work, position will pay from $25 to $30 a week. Location, within 100 miles of New York. Apply through the Society.

026 Assistant to sales manager in steam turbine business. Location, New England. Technical graduate with two or three years' experience preferred, with some executive ability. Good opportunity. Immediate answer necessary.

027 Mechanical draftsman on building and installation of street railway equipment, car barns, etc. Salary $100 to $150 a month. Location, New York.

028 Two draftsmen with experience in designing four-cylinder, four-cycle gasolene engines of sizes from 5 to 11 in. bore. Salary $150 a month. Location, Middle West.

029 Recent college graduate to take charge of machinery in small mill; if capable the applicant later to become superintendent. Location, New Jersey.

030 Man with executive ability to take charge of the engineering of a large plant; should have experience in machine design, power plants, and building construction. Applicants in answering this notice should state age, education, experience, and salary expected; give references. Norton Company, Worcester, Mass.

031 Chief draftsman, with executive ability, experience in up-to-date manufacture of interchangeable parts, resourceful in design. Location, New Jersey.

MEN AVAILABLE

22 Mechanical engineer desires position as superintendent or works engineer. Experienced executive with broad technical, commercial and practical training. Will show results accomplished in present and previous connection.

23 Member, technical education, extended experience as machinist, chief draftsman and engineer on power transmission, cement, industrial, illuminating gas and power plants, heating and ventilating installations, conveyors, estimating, appraisals and management of public service properties, at present employed but desires position with consulting engineer or public utilities corporation.

24 Position desired as assistant to purchasing agent or executive, taking care of specifications, contracts, development and research work; general mechanical, electrical, experimental and works engineering experience.

25 Associate, age 34, desires position as superintendent or works engineer: construction, railway and factory engineering experience.

26 Member desires to become identified with firm of consulting engineers, or as sales engineer for manufacturing organization. Age 35, Mass. Inst. Tech. graduate, 15 years' experience in design, erecting, testing, and experimental work, including four years' on government staff, steam engineering testing laboratory; now in charge of engineering work in post-graduate department of a leading eastern educational institution.

27 Member, age 35, 15 years' experience in operating and designing power plants, machine, car and railroad shops; good organizer and manager; desires position as mechanical and electrical superintendent with some good concern or chief engineer of a group of power plants. Would consider traveling position. Highest grade of references.

28 Member, technical graduate with 20 years' experience in the design and construction of road-making machinery, engines, boilers, motor trucks, etc. Works manager 3 years; chief engineer, 8 years. Design problems, factory accounting, cost reduction.

29 Member, age 46, experienced designer of all kinds of engines and apparatus relating to power, refrigeration and marine engineering, expert on fuel oil engines.

30 Member desires position as works manager, preferably wtih new company just starting business; long experience as factory man and engineer; at present head of engineering department of large company.

31 Sales engineer, technical graduate with wide experience, has opened New York office and can take hold of another good account on commission or part commission; will give personal attention until product is well on market.

32 Member, broad general experience along mechanical and electrical lines in both engineering and executive positions, desires connection with consulting or contracting engineers, manufacturing company or sales agency in or near New York City.

33 Member, experienced as salesman, manager, superintendent of manufacturing plant, power house work, either design or construction, desires position in New York.

34 Trained manufacturing executive experienced in problems of management, efficiency, factory and commercial accounting, general office management; technical graduate, desires position in New York State or New England territory.

35 Member with valuable experience in handling of materials, seeking position in special advisory work of this character.

36 Technical graduate, desires position with consulting engineer or with company manufacturing steam and gas machinery, especially gasolene locomotives. Available after June 25.

37 Member desires position as works manager; technical graduate, 15 years' manufacturing experience; successfully carried entire managerial responsibility. Executive ability, thoroughly able to develop factory organization in most modern methods of control of production. Familiar with high-grade interchangeable and precision work in quantity. Highest credentials.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

American Association of Public Accountants. Year Book, 25th Anniversary. *New York, 1912.*

American Society of Naval Engineers. Journal, vol. 1, nos. 1-2, 1889, *Washington, 1889.*

Beton-Kalender Taschenbuch für den Beton und Eisenbetonbau, 1913, pts. 1-2. *Berlin, 1912.*

Central Railway Club. Official Proceedings, vol. 6, nos. 1-4; vol. 7, no. 1; vol. 10, nos. 4-5; vol. 11, nos. 1, 3-5; vol. 12, no. 2; vol. 13, nos. 1-5; vol. 14, nos. 1-5; vol. 15, nos. 1, 3, 5; vol. 16, nos. 1-5; vol. 17, nos. 1-4; vol. 18, nos. 2, 3. *New York, 1900-1901, 1904-1912.* Gift of club.

Cincinnati. City Water Department. 72d Annual Report. *Cincinnati, 1912.* Gift of department.

Cocoa and Chocolate, Their Chemistry and Manufacture, by R. Whymper. *London, 1912.*

Código Civil de la Republica Oriental del Uruguay. Edición Oficial. Montevideo, 1893. Gift of Uruguay Republic de Oriental.

Drafting of Cams, Louis Rouillion, ed. 3, no. 2. *New York, 1908.*

Electric Cranes: Their Design, Construction and Application, H. H. Broughton, *London, 1911.*

Electric Power from the Mississippi River. Bull. no. 8, December, 1912. *Keokuk, 1912.* Gift of Mississippi River Power Co.

L'Electrification des Grandes Lignes de Chemins de Fer, C. O. Mailloux. *Torino, 1912.* Gift of author.

Elements of Heating and Ventilation. A textbook for students, engineers and architects, Arthur M. Greene, Jr. *New York, J. Wiley & Sons, 1913.*

The author is a member of the faculty of Rensselaer Polytechnic. The book is clearly written, with a very logical arrangement. There is a chapter on district heating and one on temperature control. A large amount of necessary data has been incorporated.

Elements of Machine Design. Part 2, W. C. Unwin and A. L. Mellanby. *London, Longmans, Green & Co., 1912.* Gift of W. C. Unwin.

The volume deals almost exclusively with steam engine details. The present edition has been largely rewritten from experience gained by the use of the former edition in the Royal Technical College, Glasgow. New chapters on governors and condensers have been added.

Engineering as a Vocation, Ernest McCullough. *New York, D. Williams Co., 1911,*

Beginning with a short history of the engineering profession and giving the definition of an engineer as given by various authorities, the author proceeds to take up engineering as a vocation, describing the education of the engineer, the value of a technical education, and discusses fully the commercial side of the engineer's profession. For instance, one of the titles of his chapters is How to Hunt and Hold a Job. It would seem that all engineers might read this book with great interest and that its perusal would broaden their point of view.

ENGINEERING OF SHOPS AND FACTORIES, H. G. Tyrrell. *New York, 1912,*

ENGINEERING RECORD, vols. 17, 18. *New York, 1887-1888.*

DIE ENTSTEHUNG DES DIESELMOTORS, R. Diesel. Schiffbautechnische Gesellschaft, 1912. Gift of R. Diesel.

LES ESSAIS DE GONFLEMENT À L'EAU CHAUDE, R. Feret. Reunion des membres Française et Belges de L'Association Internationale pour l'Essai des Matériaux. Gift of C. W. Rice.

ÉTUDE SUR LES LOCOMOTIVES DE MONTAGNE ET PARTICULIEREMENT LA LOCOMOTIVE COMPOUND ARTICULÉE SYSTÉME MALLET, M. A. Mallet. *Paris, 1912.* Gift of author.

FARM GAS ENGINES, H. R. Brate. *Cincinnati, 1912.*

GEORGE VON REICHENBACH (Biography), Walther V. Dyck. *München, 1912.* Gift of Deutsches Museum.

HANDBUCH DER MATERIALIENKUNDE FÜR DEN MASCHINENBAU, I. A. Martens *Berlin, 1898.*

HEIZUNGS, LÜFTUNGS UND DAMPFKRAFTANLAGEN, IN DEN VEREINIGTEN STAATEN VON AMERIKA, A. K. Ohmes. *München, 1912.*

INDIANA ENGINEERING SOCIETY. Proceedings 31st and 32d Annual Convention, 1911-1912. *Indianapolis, 1911-1912.* Gift of society.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS. Proceedings 40th Annual Convention, 1912. *Roanoke, 1912.* Gift of association.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION. Proceedings July 23-26, 1912. *Chicago, 1912.* Gift of association.

JAHRBUCH DER MOTORLUFTSCHIFF-STUDIENGESELLSCHAFT. vol. 5, 1911-1912. *Berlin, 1912.*

DIE KALKULATION IM METALLGEWERBE UND MASCHINENBAU, Ernst Pieschel. *Berlin, 1912.*

LEHRBUCH DER TECHNISCHEN PHYSIK, Paul Müller. *Berlin, 1912.*

THE LOCOMOTIVE. vols. 1-4, 6-15, 1880-1883, 1885-1894. *Hartford, 1880-1883, 1885-1894.* Gift of F. A. Halsey.

MARINE STEAM TURBINES, G. Bauer and O. Lasche. Translated from the German and edited by M. G. S. Swallow. *New York, 1911.*

DIE MASCHINEN-ELEMENTE, M. Schneider. 2 vols. *Braunschweig, 1903.*

METALLOGRAPHIE. pts. 7-12. *Berlin, 1911-1912.*

MODERN GASOLINE AUTOMOBILE, ITS CONSTRUCTION, OPERATION, MAINTENANCE AND REPAIR, V. W. Page. *New York, 1913.*

NEW YORK CENTRAL AND HUDSON RIVER RAILROAD COMPANY WOOD BOILERS TEST No. 907. Report by J. W. Harkom. December, 1912. *Media, 1912.* Gift of W. H. Wood Loco Fire Box and Tube Plate Co.

NEW YORK STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY. How to increase the Durability of Fence Posts, Shingles and other Farm Timbers. *Syracuse, 1912.* Gift of college.

PETITS MODÈLES D'AEROPLANES, E. H. Dollfus. *Paris, 1912.*

THE PITOT TUBE APPLIED TO THE MEASUREMENT OF AIR, L. Loeb. Reprinted from Journal of the American Society of Naval Engineers, November, 1912. Gift of author.

Polytechnic Institute of Brooklyn. President's Annual Report. October, 1912.

Progress of Warship Engineering. By C. de Grave Sells. n.p. n.d. Gift of author.

Propellers, C. H. Peabody. *New York, 1912.*

Railroad Operating Costs, Suffern & Son. vol. 2. *New York, 1912.*

Report on Development of Transit System. pt. 1, Transportation Facilities for Panama-Pacific Exposition at Harbor View to the Board of Supervisors City of San Francisco, B. J. Arnold. Preliminary Report No. 10, December 2, 1912. Gift of author.

Shipping Casualties. Loss of the Steamship "Titanic." Report of a formal investigation into the circumstances attending the foundering on 15th April, 1912, of the British Steamship "Titanic" of Liverpool, after striking ice in or near latitude 41° 46′ N., longitude 50° 14′ W., North Atlantic Ocean, whereby loss of life ensued. *London, 1912.* Gift of John R. Freeman.

Southwestern Electrical and Gas Association. Proceedings and Question Box, 7th Annual Convention, 1911. *Houston, 1911.* Gift of association.

Steam Economy in the Sugar Factory, Karl Abraham. Translated by E. J. Bayle. *New York, J. Wiley & Sons, 1912.*

The translator is engineer of the American Beet Sugar Company. The author follows the various operations in a beet sugar factory, and works out formulæ for the heat losses. An unusual feature is the insertion between pages of the text of pages of cross-section paper.

Report on Traffic and Service in the Downtown District to the Board of Supervisors City of San Francisco. Preliminary Report No. 11, December 23, 1912, B. J. Arnold. Gift of author.

Steam Engine and Gas and Oil Engines, John Perry. *London, 1909.*

Traveling Engineers' Association. Proceedings 20th Annual Convention. *Buffalo, 1912.* Gift of association.

Una-Flow Steam Engine, J. Stumpf. *Munich, 1912.* Gift of Ed. H. Trump.

The straight-flow steam engine may be said to have passed the experimental stage (there are now working or in actual construction engines with an aggregate output of more than 500,000 h.p.) and a book on its principles and construction in English is certainly in order, particularly when written by a man as eminently qualified to speak on this subject as the inventor himself. The purpose of the straight-flow engine is to do in one cylinder what is usually done in several. To do this, the working steam is allowed to enter from below into the hollow cover, where it heats the surfaces of the cover and then passes by a valve in the upper part of the cover into the cylinder; it then follows the piston while giving up its energy and after it has expanded, passes out at the end of the piston stroke through the exhaust ports arranged in the middle of the cylinder and controlled by the piston. By eliminating all cooling of the clearance surfaces by the exhaust steam an effect is obtained somewhat similar to that usually produced by superheating, while the use of a ring of exhaust ports or slots in the cylinder enables the area of the exhaust passage to be made three times as great as the port area obtained by the use of slide or other valves. The result of this large exhaust area is that the end pressure in the cylnider is that of the condenser, especially when the use of long and narrow pipe connections between the condenser and the cylinder is avoided. The peculiar characteristic of the straight-flow steam engine is that, as a single cylinder engine, it works with saturated steam just as economically as with superheated. That does not mean, of course, that superheating the steam is of no value whatever. All along the way up to the admission valve the economy of superheating even in straight-flow engines is quite material, but once inside the cylinder, dry saturated steam gives as good results economically as superheated, owing to economy in lubrication. Superheats far higher than usual may be used in the straight-flow engine, because the last part of the expansion line falls, even with the highest initial temperatures, below the saturation line, and even with a hot steam jacket on the cover, practicable working temperatures are obtained for the cylinder and cover. All this makes it worth while for the American steam engineer to gain a closer acquaintance with this type of engine, which is less known in this country than it deserves to be. The book is well written and edited. The selection of the term "Una-flow" is unfortunate: "uni-flow" or "straight-flow" are better known and have a more English sound.

U. S. AGRICULTURE DEPARTMENT. Report of the Director of the Office of Public Roads, 1912. *Washington, 1912.* Gift of department.

U. S. INTERSTATE COMMERCE COMMISSION. First Annual Report of the Chief Inspectors of Locomotive Boilers. October 5, 1912. *Washington, 1912.*

URUGUAY. ANUARIO ESTADISTICO DE LA REPUBLICA ORIENTAL. Vol. 2, pt. 3, 1908. *Montevideo, 1911.* Gift of Uruguay Republica de Oriental.

VALUATION OF PUBLIC SERVICE PROPERTIES, L. R. Nash, ed. 2. Reprinted from the Stone & Webster Public Service Journal, October, 1912. Gift of Stone & Webster Engineering Corporation.

UNITED ENGINEERING SOCIETY

GARY PUBLIC LIBRARY. LIST OF BOOKS ON ELECTRICITY, CIVIL ENGINEERING, MECHANICAL ENGINEERING, CHEMICAL TECHNOLOGY AND CHEMISTRY. *Indianapolis, 1912.* Gift of library.

IOWA BOARD OF RAILROAD COMMISSIONERS, 34th Annual Report, 1911. *Des Moines, 1912.* Gift of American Electric Railway Association.

KANSAS GAS, WATER, ELECTRIC LIGHT AND STREET RAILWAY ASSOCIATION. Official Convention Proceedings, 15th Annual Meeting. *Kansas, 1912.* Gift of association.

MAP OF THE ISLAND OF PORTO RICO, SHOWING MACADAMIZED ROADS, RAILROADS AND GENERAL TOPOGRAPHY. Gift of the Photoprint Co.

NORTH CAROLINA.. CORPORATION COMMISSION. 13th Annual Report, 1911. *Raleigh, 1912.* Gift of American Electric Railway Association.

UNIVERSAL ENGLISH-GERMAN AND GERMAN-ENGLISH DICTIONARY, Felix Flügel, pt. 2. *Braunschweig, 1912.*

GIFT OF J. W. LIEB, JR.

BOLLETTINO DELL ASSOCIAZIONE FRA GLI EX-ALLIEVI DEL POLITECNICO MILANESE FONDATA NEL 1902. Vol. 1-3, 1865-1909. *Milano, 1904, 1907, 1910.*

QUARANTASEI ANNI DI VITA DEL R. ISTITUTO TECNICO SUPERIORE DI MILANO, 1863-1909. Monografia del Vicedirettore. Prof. Antonio Sayno. *Milano.*

R. ISTITUTO TECNICO SUPERIORE DI MILANO.. Programma Anno 1911-1912. *Milano, 1912.*

GIFT OF ERNST REITLER

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS. Zurich, 1895. Protokolle, der verhandlungen des V. Internationalen Kongresses zur Vereinbarung einheitlicher Prüfungs-methoden von Bau und Konstruktions-Materialien. Procès-Verbaux.

———Stockholm, 1897. Rapport presente par Ad. Carnot.

———Budapest, 1901. Metallographie et Mecanique, F. Osmond & G. Cartaud. *Stuttgart, 1901.*

———Über den Einfluss einiger Salze auf den Abbinde und Erhärtungsprozess des Portland-Cementes, L.v. Tetmajer. *Zurich, 1901.*

———Proceedings of the Congress September 9-14, 1901.

———Brussels, 1906. 65 pamphlets.

GIFT OF WM. PAUL GERHARD

The Society wishes to thank Dr. Wm. Paul Gerhard for a large number of interesting books and pamphlets which he has placed at the disposal of the United Engineering Society Library.

EXCHANGES

AMERICAN SOCIETY OF CIVIL ENGINEERS. Transactions, vol. 75. *New York, 1912.*

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings, vol. 189. *London, 1912.*

INSTITUTION OF MECHANICAL ENGINEERS. General Index to Proceedings, 1901-1910. *London, 1910.*

INSTITUTION OF NAVAL ARCHITECTS. Index to Transactions, vols. 47-54, 1905-1912. *London, 1912.*

U. S. LIBRARY OF CONGRESS. Report of Librarian, 1912. *Washington, 1912.*

———Publications of the Library issued since 1897. *Washington, 1913.*

TRADE CATALOGUES

BABCOCK & WILCOX CO., *New York.* Stirling water tube boiler, 1912, 63 pp.

CHICAGO PNEUMATIC TOOL CO., *Chicago, Ill.* Bull. E-22, heavy duty electric drills for alternating current, December 1, 1912; Bull. E-26, universal electric drills operating on direct or alternating current, December 1, 1912; Bull. E-27, heavy duty electric drills, December 1, 1912; Bull. E-34-G, air receivers, after coolers, air line, drain traps, etc., November, 1912.

EDWARD STEAM SPECIALTY CO., *Chicago, Ill.* Cat. No. 5, valves and fittings, 1913.

ERIE CITY IRON WORKS, *Erie, Penn.* Economic return tubular boiler, 8 pp.; Erie City vertical water tube boiler, 19 pp.; Progression and the Lentz engine.

HESS-BRIGHT MFG. CO., *Philadelphia, Pa.* Ball bearing engineering (data sheet), 1912.

JOHNS-MANSVILLE CO., *New York.* J-M Power Expert, December 1912.

METALLIC PACKING & MFG. CO., *Elyria, Ohio.* Description of packing rings.

PRATT & WHITNEY CO., *Hartford, Conn.* Adjustable multiple spindle drills, 1911, 32 pp.

TIMKEN ROLLER BEARING CO., *Canton, Ohio.* Timken primer on the anatomy of automobile axles, ed. 2, 1912, 52 pp.; on the care and character of bearings, ed, 2, 1912, 30 pp.; roller bearings.

UNDER-FEED STOKER CO., *Chicago, Ill.* Publicity Magazine, December 1912.

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- G. M. Basford
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- D. S. Jacobus
- E. D. Meier

Changes in the Patent Laws of U. S.

- W. H. Blauvelt
- B. F. Wood
- Carl Thomas
- Edward Weston
- W. E. Winship

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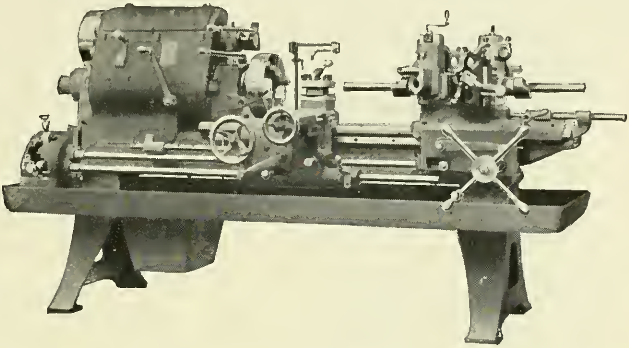

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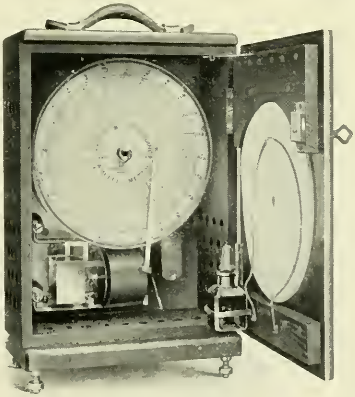

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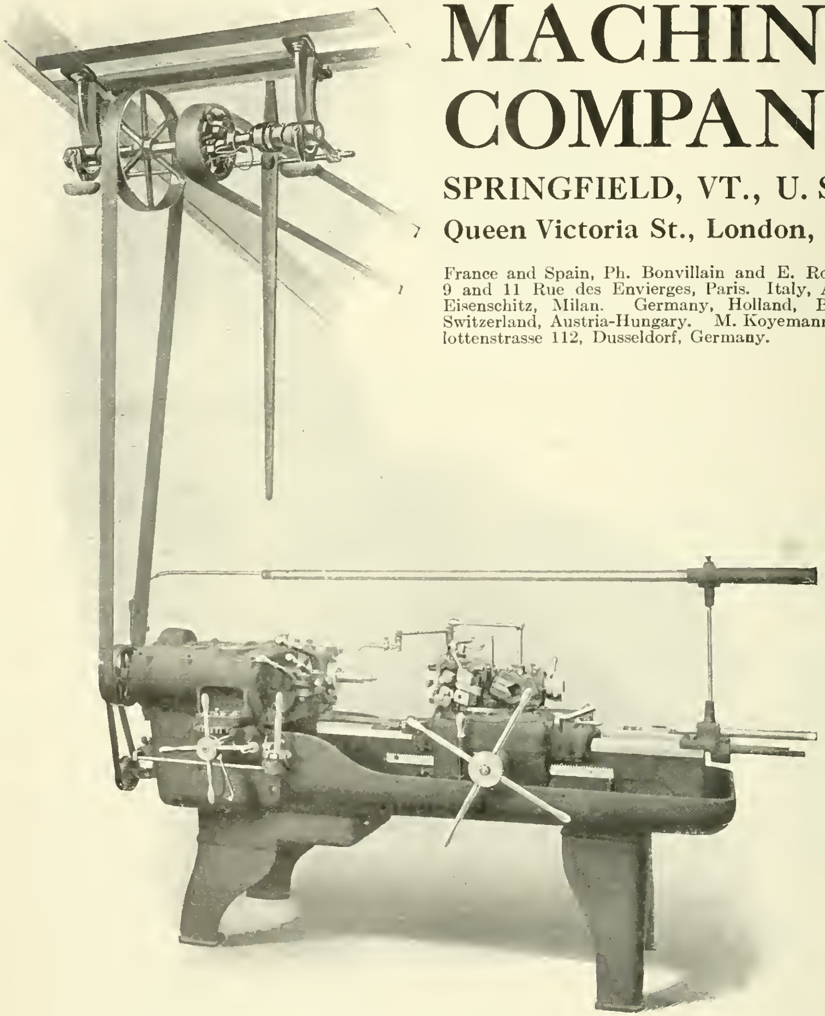

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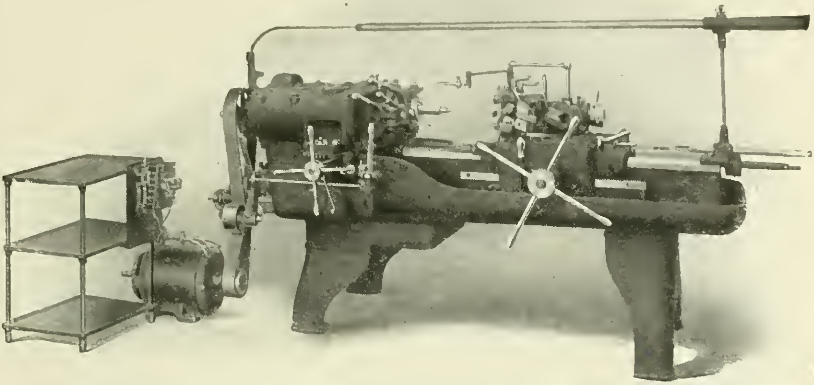

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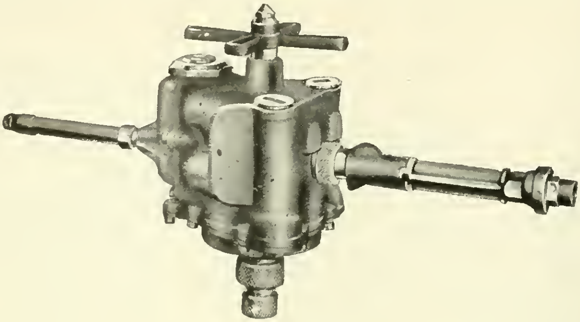

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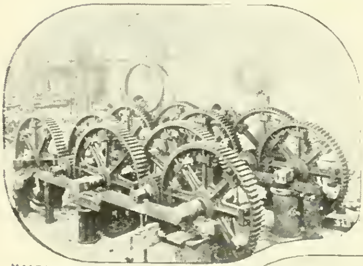

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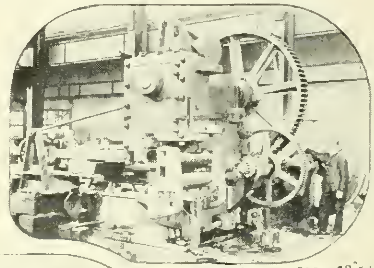

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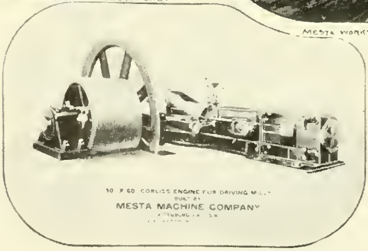

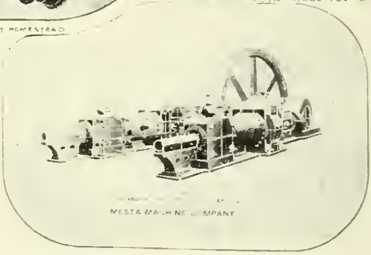

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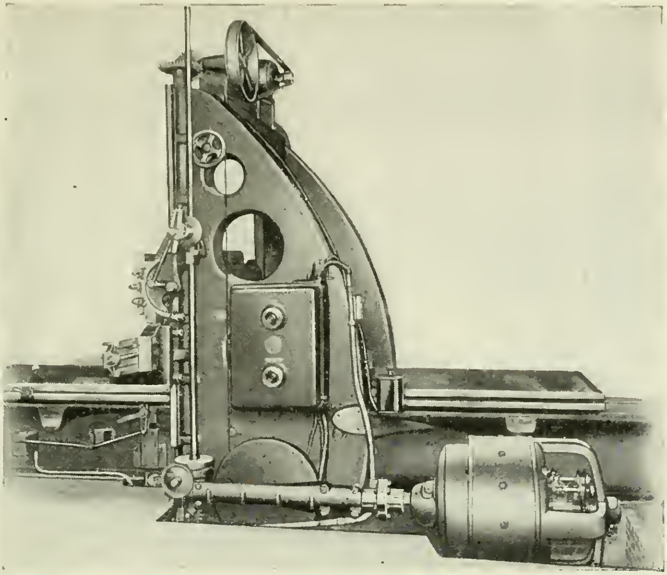

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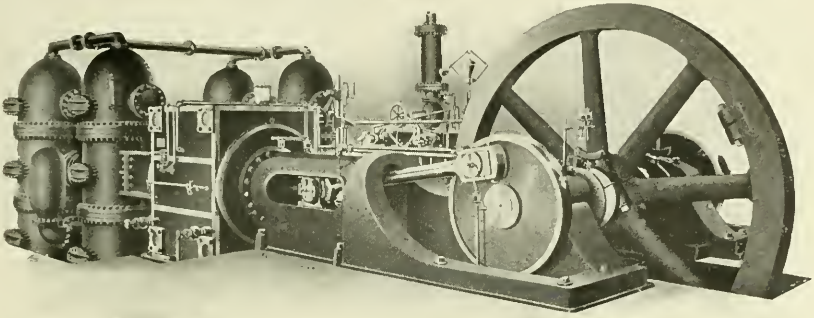

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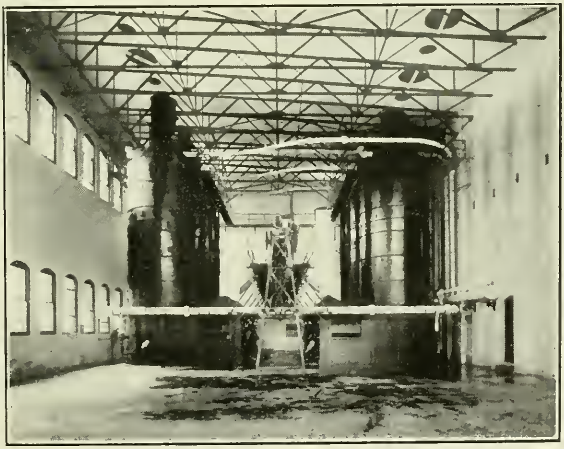

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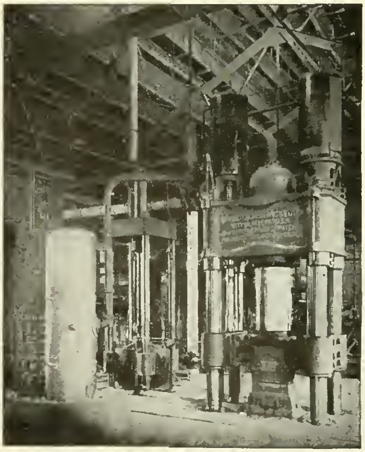

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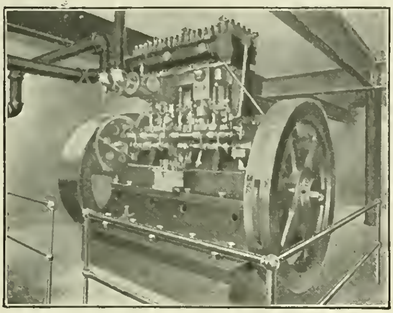

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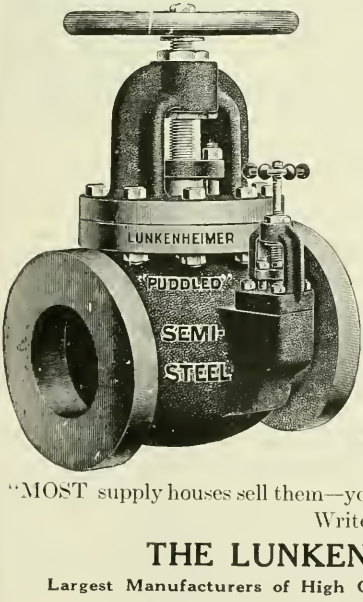

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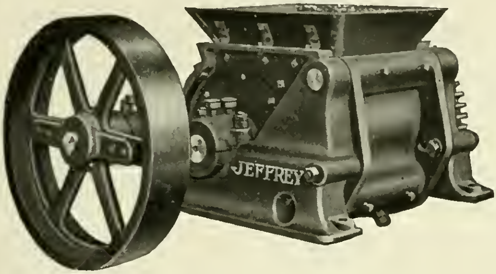

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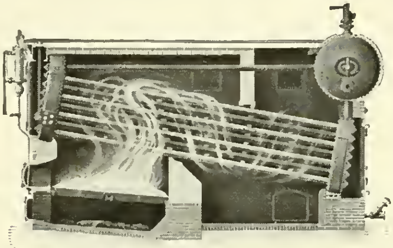

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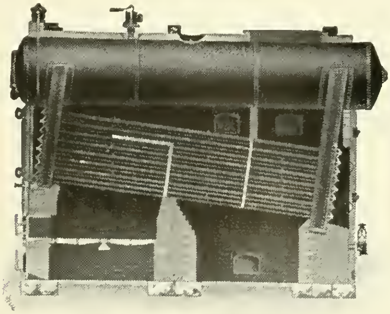

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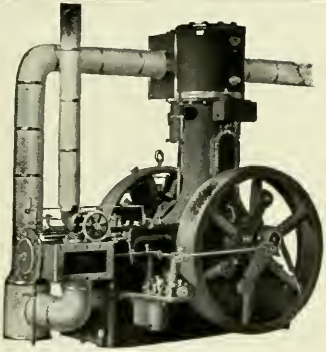

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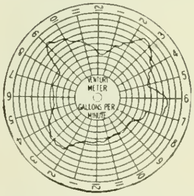

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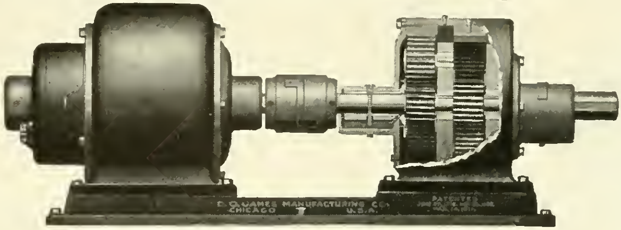

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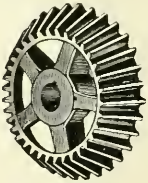

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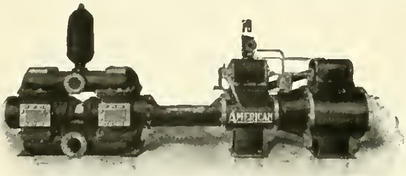

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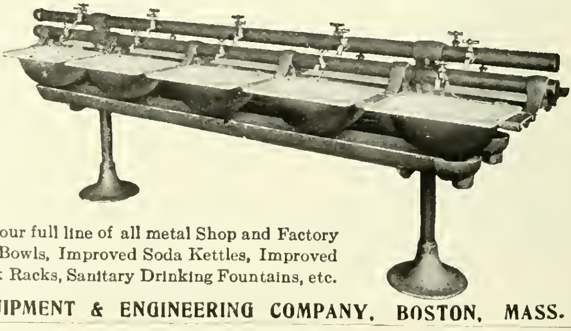

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THE
JOURNAL
of

THE AMERICAN SOCIETY
OF MECHANICAL ENGINEERS

MARCH 1913

35 CENTS A COPY **$3 A YEAR**

MONTHLY MEETINGS: NEW YORK, MARCH 13; CINCINNATI, MARCH 20; BOSTON, MARCH 25; NEW HAVEN, APRIL 16; SPRING MEETING: BALTIMORE, MAY 20–23; MEETING IN GERMANY: JUNE 21–JULY 8

THE PROFESSIONAL SERVICE SHEET

On March 17 the Professional Service Sheet will be mailed to the voting membership, and the Committee wishes to emphasize in connection therewith the following:

A careful reading of the records of those who have applied for admission to the Society must convince every member that the campaign which this Committee is carrying on is resulting in securing the applications of a very large number of the leading engineers of the country. A good start has been made and the Committee is hopeful that what has been accomplished will give the membership confidence that the movement is in the right direction, and that each member will support the Committee by enlisting the interest of the highest class of engineers, and securing their applications for membership.

APPOINTMENT OF SUB-COMMITTEES

Sub-committees of the Committee on Increase of Membership have been appointed in several localities, and a list with the Chairman of each is given herewith:

Boston,	A. L. Williston	*Philadelphia,*	T. C. McBride
Buffalo,	W. H. Carrier	*St. Louis,*	John Hunter
Chicago,	H. V. O. Coes	*St. Paul,*	Max Toltz
Cincinnati,	J. T. Faig	*San Francisco,*	Thos. Morrin
Detroit,	H. W. Alden	*Seattle,*	R. M. Dyer
New York,	James A. Kinkead		

Members in these localities who are willing to cooperate in this work are requested to communicate with the Chairman of the Sub-committee.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chairman*

F. H. Colvin
J. V. V. Colwell
J. P. Ilsley
E. B. Katte
H. V. O. Coes
W. R. Dunn
R. B. Sheridan
H. Struckmann

MARCH 1913 VOL. 35 No. 3

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

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The Journal is published monthly by The American Society of Mechanical Engineers.
Price, 25 cents a copy, or $2 a year, to members and affiliates of the Society; 35 cents a copy or $3 a year to all others. Postage to Canada, 50 cents additional; to foreign countries, $1 additional
Entered as second-class matter, January 4, 1912, at the Postoffice, New York, N. Y., under the act of March 3, 1879.

COMING MEETINGS OF THE SOCIETY

March 13 (*Thursday*), *New York City*, Engineering Societies Building. Joint Meeting with the Society of Illuminating Engineers and the American Museum of Safety. Addresses: Industrial Lighting, by Ward Harrison, engineering department, National Electric Light Association; How to Prevent Fifty Per Cent of Industrial Accidents, by Dr. W. H. Tolman, director, American Museum of Safety; also an address by Dr. Alger of the Sage Foundation for the Prevention of Blindness. Discussion is invited, and all persons who intend to participate should communicate with F. A. Waldron, 37 Wall Street, New York. Informal dinner, 6.30 p.m., Keen's English Chop House, 70 W. 36th St. Kindly notify H. R. Cobleigh, 505 Pearl St., of intention to be present.

March 20, Cincinnati, Ohio, Address: Engineering and Common Sense, Wm. Kent.

March 25, Boston, Mass. Paper on Textiles, Frank W. Reynolds.

April 8, *New York City*, Engineering Societies Building. In charge of the Sub-Committee on Railroads. Subject: Steel Car Construction. To be discussed by W. F. Keisel, Jr., E. W. Summers, J. A. Pilcher, H. A. Currie, F. W. Butt, H. M. Estabrook, S. P. Bush, C. T. Westlake, and others. See further details on page 5.

April 16, *New Haven, Conn.*, Mason Laboratory, Yale University. Subject for afternoon session: Factory Heating; for evening session, Factory Lighting.

May 20–23, *Baltimore, Md.*, Spring Meeting. Headquarters, Hotel Belvedere. See Tentative Program on page 3.

June 21–*July* 8, Joint Meeting with Verein deutscher Ingenieure, Leipzig, and various industrial cities of Germany. See page 7 for Tentative Program.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 35 MARCH 1913 NUMBER 3

THE SPRING MEETING

The program for the Spring Meeting at Baltimore, May 20–23, has been tentatively arranged by the Committee on Meetings and the Local Committee at Baltimore. The headquarters will be the Hotel Belvedere and the professional sessions and various social functions will also be held at the Belvedere. The meeting will open on Tuesday evening with an informal reception; on Wednesday and Thursday mornings there will be professional sessions, and Wednesday and Thursday afternoons will be devoted to excursions, with an entertaining lecture on Wednesday evening and a reception and dance on Thursday evening. The whole day on Friday will be occupied with a trip to Annapolis.

It is the purpose of the Committee on Meetings to reduce the number of professional meetings to a few strong sessions at which, because of their great interest, there will be a large attendance and thorough discussion. As at present arranged, these are to be confined to three sessions. The opening one on Wednesday morning will consist of a brief business meeting, followed by papers on certain phases of the patent situation and the performance of automobile trucks. Simultaneous with this will be the meeting of the Gas Power Section, for which two papers are promised, one on oil-engine practice abroad, and one on blast-furnace gas. On Thursday morning, the whole session will be devoted to the subject of fire protection, two of the papers being published in this issue, upon the new high-pressure fire system at Baltimore, and the important question of standard couplings for fire apparatus. Supplementing this meeting there will be a demonstration of the high-pressure fire system in the afternoon, with trips also to inspect other public works, including the sewage disposal plant.

The Local Committee, Layton F. Smith, Chairman, have carefully prepared the program for entertainment, under the supervision of a special committee, and these events, which are outlined herewith, should not only be most enjoyable, as is always the case when members of the Society come together, but of real interest because of the opportunities which the city of Baltimore is able to offer.

In accordance with what is deemed to be a wise policy for the Society to adopt for its various meetings, the Committee on Meetings have urged that the Local Committee permit the visiting members to share in the expenses of the entertainment to the extent of paying for their fares, luncheons, and similar expenditures, rather than burden local members with the necessity of raising funds for these purposes.

As the meeting is to be held at a time of the year when there are many visitors in Baltimore, members are urged to make their hotel reservations early. These must be made personally in every instance. Besides the Belvedere, there is the Stafford, which is only three and one-half blocks away, and the Hotel Emerson which is an eight-minute ride on the trolley.

TENTATIVE PROGRAM

Tuesday, May 20

8.00 p. m.	Informal Reception at headquarters

Wednesday, May 21

9.30 a. m.	Business Meeting at Headquarters Professional Session with miscellaneous papers Gas Power Session
12.30 p. m.	Excursion to McCall's Ferry, Dam and Power House. If a sufficient number desire to make this trip, a special train will be provided at $1.80 per passenger for the round trip; otherwise the fare of $2.68 will be charged Other trips will be arranged for those who do not desire to visit the power plant The ladies will participate in an automobile trip, with tea served at the Country Club
Evening	Lecture at Headquarters; subject and speaker to be announced later

Thursday, May 22

9.30 a. m.	Session on Fire Protection at Headquarters
Afternoon	Trip over Jones' Falls conduits, inspection of sewerage pumping plant, and trip by trolley to sewage disposal plant at Back River Exhibition of high-pressure fire service
Evening	Reception and Dance at Headquarters. The members will be the guests of the Engineers Club of Baltimore on this occasion

Friday, May 23

The entire day will be devoted to a trip to Annapolis. The party will leave Baltimore at 9 a.m., by a commodious excursion steamer, going down the Patapsco River, past Fort McHenry and other forts, Sparrows Point, down the Chesapeake Bay, into the Severn River, and thence to Annapolis. This is a trip of unusual beauty. Upon arrival the Society will be welcomed at the Governor's mansion, after which there will be opportunity to visit points of interest. The Society will be accorded the privilege of the use of the House of Delegates and the Senate Chamber for such meetings as it may desire to hold. An address will be given at the Capitol at 2 p.m. by Admiral H. I. Cone, Mem.Am.Soc.M.E., Engineer-in-Chief of the Bureau of Steam Engineering, U. S. N., upon the United States Experimental Station at Annapolis.

Following this members interested may inspect the station. It is understood that there will be hydroaeroplane flights by officers and men of the aviation school, and possibly some evolutions of the submarine boats stationed at Annapolis at that time. The Naval Academy will be open for inspection during the afternoon.

The expenses of the trip will be $3, including luncheon and supper. Those desiring to return early may do so by electric trolley, the ride to Baltimore taking one and one-half hours.

MEETINGS IN CHICAGO

The recently organized Chicago section of the Society held its first regular professional meeting on February 6, a report of which is given at the back of this issue of The Journal. Previously two organization meetings had been held, as reported in the February number of The Journal. At the recent meeting the subject for discussion was Combustion Engines, with addresses by E. T. Adams, Prof. Chas. R. Richards, J. C. Miller, Nisbet Latta, and others. About 65 were in attendance and the discussion was of exceptional value, giving promise of marked success and a growing interest for future meetings. There is every reason to believe that one of the largest and strongest groups of the Society will be gradually developed in Chicago in the spirit of coöperation which has been manifest in other cities. In this way the local sections of the other national societies in Chicago, the Western Society of Engineers, the Engineers Club, and our own organization, can be of mutual service in the promotion of the various branches of engineering.

NEW YORK MEETING, APRIL 8

There is a large representation of railroad men in the membership of the Society, and on April 8 the regular New York meeting will be in the interests of this part of the membership and of railroad men generally in the vicinity of New York. The subject of Steel Car Construction has been assigned to the meeting, and the Sub-Committee on Railroads, which held such a successful session at the Annual Meeting, will have charge of the program. So far as known there has never been a meeting of engineers to discuss steel car construction, and it is the intention to bring before the Society the very latest developments of the art by specialists in each feature of steel passenger car design. It will be a meeting that should fill the auditorium.

The speakers who have accepted and the subjects assigned to them are given below, and other phases of the subject will be presented by other authorities, announcement of which cannot be made until later.

Problems of Steel Car Designs, W. F. Kiesel, Jr., assistant mechanical engineer, Pa. RR. Co.

Suspension of Steel Cars, E. W. Summers, Summers Steel Car Co.

Trucks for Steel Passenger Cars, J. A. Pilcher, mechanical engineer, Norfolk & Western Ry.

Provision for Electric Lighting in Steel Cars, H. A. Currie, assistant electrical engineer, N.Y.C. & H.R.R.R. Co.

Provision for Electrical Equipment on Steel Motor Cars, F. W. Butt, assistant engineer, N.Y.C. & H.R.R.R. Co.

Special Ends for Steel Passenger Cars, H. M. Estabrook, president, Barney & Smith Car Co.

Draft Gears for Steel Passenger Cars, S. P. Bush, Buckeye Steel Castings Co.

Cast Steel Double Body Bolts and End Frames for Steel Cars, C. T. Westlake, chief mechanical engineer, Commonwealth Steel Co.

AMERICAN ACADEMY OF POLITICAL AND SOCIAL SCIENCE

The seventeenth annual meeting of the American Academy of Political and Social Science will be held in Philadelphia on April 4 and 5, 1913, and will partake of the nature of a National Conference. The entire six sessions will be devoted to the subject of the cost of living in the United States. The leading professional and commercial organizations of the country have been invited to participate, with the idea of securing enlightenment, through interchange of opinion, on the different phases of this important question.

MEETING IN GERMANY, 1913

The itinerary of the visit of the Society to Germany by invitation of the Verein deutscher Ingenieure and in connection with its annual meeting will be as follows:

TENTATIVE PROGRAM

NEW YORK

Tuesday, June 10

10.00 a. m. The party sails on the Hamburg-American S. S. Victoria Luise (remodeled "Deutschland") from Hoboken. It will be advisable for members of the party to reach New York not later than June 9.

Representatives of the Verein deutscher Ingenieure will come on board at Cherbourg to receive the visitors.

HAMBURG

Thursday, June 19

Arrival in Hamburg.

Friday, June 20

11.00 a. m. Address: The Hamburg Harbor
11.00 a. m. to 1.00 p. m. Trip around the harbor
5.30 p. m. Reception in the Municipal Hall by the Senate of the city and by the Hamburg Section of the Verein deutscher Ingenieure

Saturday, June 21

10.00 a. m. Excursions
Group 1: Inspection of the Elbe tunnel and visit to the shipyards of Blohm and Voss
Group 2: Visit to the Vulcan yards and inspection of the Elbe tunnel

Sunday, June 22

10.00 a. m. Departure for Leipzig

LEIPZIG

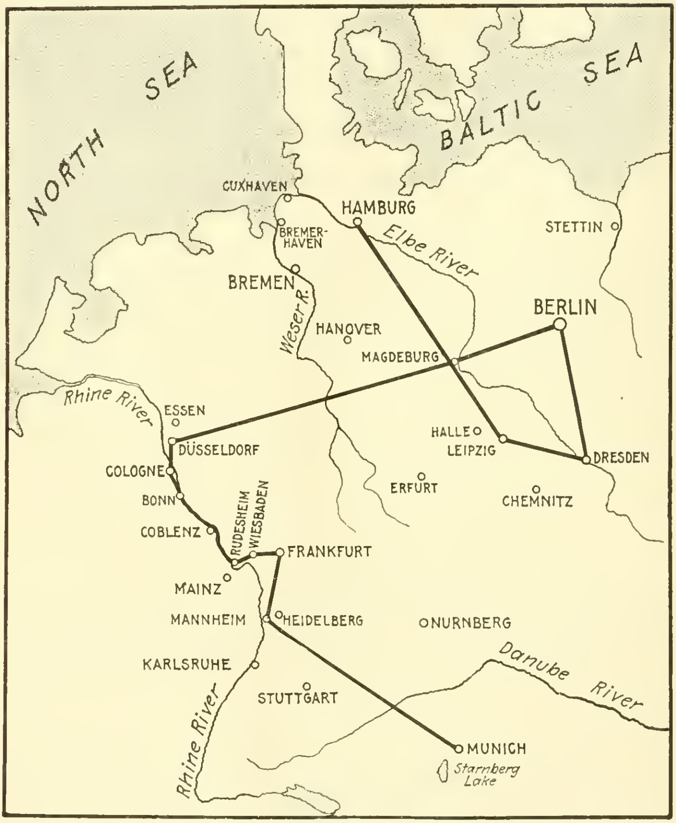
Sunday, June 22

4.30 p. m. Arrival in Leipzig
8.00 p. m. Reception in the Crystal Palace

LEIPZIG

Monday, June 23

10.00 a. m.	Formal meeting in the Municipal Hall
5.00 p. m.	Concert under the direction of Mr. Arthur Nikisch in the Gewandhaus
7.30 p. m.	Formal dinner in Central Theater



Itinerary of Official Tour in Germany

Tuesday, June 24

9.30 a. m.	Scientific Lectures in the lecture room of the Architectural Exhibition
4.30 p. m.	Inspection of the Monument of the Battle of Nations in commemoration of 100th anniversary of the battle of Leipzig, 1813
8.00 p. m.	Festival in the Palm Garden .

LEIPZIG

Wednesday, June 25

9.10 a. m. Departure for Dresden

DRESDEN

Wednesday, June 25

11.00 a. m. Arrival in Dresden
2.00 p. m. Gather at the Belvedere; automobile trip to the Saxon Switzerland (Bastei), walk to Rathen, by steamer to Pirna, by automobile to Dresden.
8.30 p. m. Reception in the Municipal Building, tendered by the city of Dresden.

Thursday, June 26

9.30 a. m. Excursion through Dresden
    Group 3: Machine Laboratory of the Technical High School
    Group 4: Seidel & Naumann Sewing Machine and Bicycle Factory
    Group 5: Picture Gallery
12.30 p. m. Lunch in the Neustadt railway terminal
2.00 p. m. Departure for Berlin

BERLIN

Thursday, June 26

5.00 p. m. Arrival in Berlin
8.00 p. m. Reception in the Reichstag Building

Friday, June 27

9.30 a. m. Excursions
    Group 6: Allgemeine-Elektricitäts Gesellschaft
    Group 7: Siemens-Schuckert Works
    Group 8: Bergmann Electrical Company
    Group 9: Ludwig Loewe Company, Machine Tool Factory
    Group 10: A. Borsig Locomotive Works in Berlin-Tegel
    Group 11: Ladies' excursion and lunch
8.00 p. m. Formal dinner in the Zoological Garden

Saturday, June 28

2.30 p. m. Automobile trip to Potsdam and steamer trip on the Havel
7.00 p. m. Entertainment by the Berlin Local Section in Wannsee

Sunday, June 29

8.00 a. m. Departure for Düsseldorf, Rhine-Westphalia

DÜSSELDORF

Sunday, June 29

6.00 p. m. Arrival in Düsseldorf
8.00 p. m. Reception in the City Hall tendered by the city of Düsseldorf

DÜSSELDORF

Monday, June 30

9.00 a. m. Excursions
- Group 12: Duisburg works of the German Machine Works Company (50 participants)
- Group 13: Friedrich-Alfred steel plant of the Friedr. Krupp Co. in Rheinhausen (75 participants)
- Group 14: Machine Works of Thyssen & Co. in Muhlheim (Ruhr) (20 participants)
- Group 15: Gutehoffnung Steel Plant, Oberhausen Rheinland (40 participants)
- Group 16: Rhein Steel Works, Duisburg-Meiderich (50 participants)
- Group 17: In the morning the ladies inspect the city of Düsseldorf, and in the evening the welfare activities of Friedr. Krupp Co. in Essen
- Group 18: Afternoon inspection of the Duisburg-Ruhrort harbor by the members of groups 12 to 16, as well as others who apply for it

The other visitors will be afforded an opportunity to see the city of Düsseldorf

8.00 p. m. Banquet in the city concert hall of Düsseldorf tendered by the Rhine-Westphalian Section of the Verein deutscher Ingenieure

Tuesday, July 1

9.00 a. m. Excursions
- Group 19: Haniel & Lueg, Düsseldorf-Grafenberg (50 participants)
- Group 20: Ernst Schiess Company, Düsseldorf (50 participants)
- Group 21: German Machine Works Company, Benrath plant, Benrath (50 participants)
- Group 22: Steel Works of Becker Company, Willich b./Krefeld (75 participants)
- Group 23: Trip into the mountains; inspection of the Elberfeld Lift railway, Barmer mountain railway, steel plant of Rich. Lindeberg Company, Remscheid-Hasten and the Mungsten Bridge
- Group 24: The ladies will inspect some installations in the city of Düsseldorf

4.30 p. m. Departure for Cologne. Members of Group 23 go from Remscheid direct to Cologne

COLOGNE

Tuesday, July 1

5.30 p. m. Arrival in Cologne

8.00 p. m. Informal gathering in the Zoological Garden of Cologne tendered by the Rhine-Westfalen Board. Trip on the Rhine with illumination of the city and cathedral

COLOGNE

Wednesday, July 2

9.00 a. m. Excursions
  Group 25: Dye Works, formerly Friedr. Bayer & Co. Leverkusen (up to 100 participants)
  Group 26: Gas Engine Works, Deutz, Cologne-Deutz (up to 100 participants)
  Group 27: Machine Works Humboldt, Cologne-Kalk (up to 100 participants)
  Group 28: The ladies inspect the cathedral and city
8.00 p. m. Reception in Gurzenich tendered by the city of Cologne

Thursday, July 3

8.00 a. m. Departure by rail for Coblenz; thence on the Rhine by steamer to Rüdesheim, where there will be a festival on the banks, and thence by rail to Frankfort-on-Main

FRANKFORT-ON-MAIN

Thursday, July 3

6.00 p. m. Arrival in Frankfort-on-Main
8.00 p. m. Reception in the Palm Garden by the Frankfort Section of the Verein deutscher Ingenieure

Friday, July 4

11.30 a. m. Welcome by the city in Roemer. Luncheon
2.30 p. m. Excursions
  Group 29: Eastern port and gas works
  Group 30: Stockyards and gasholders
  Group 31: Refuse destroyer plant and filters
  Group 32: Inspection of the old city, Goethe house, Historical Museum
  Group 33: Visit to Saalburg
7.30 p. m. Independence Day celebration with the American colony

Saturday, July 5

10.30 a. m. Departure for Mannheim

MANNHEIM

Saturday, July 5

12.00 m. Arrival; lunch in the Friedrichspark
Excursions
  Group 34: Machine Works, Heinrich Lanz
  Group 35: Machine Works, Sulzer Bros. in Ludwigshafen
  Group 36: Brown-Boveri & Co., electric machinery
  Group 37: Cement Works in Leinen and their welfare activities

Group 38: Benz & Co. Rhine Automobile and Motor Works Company
Group 39: Inspection of the port (steam flour mills in Ludwigshafen)
8.00 p. m. Reception of welcome

Sunday, July 6

11.00 a. m. Departure for Heidelberg

HEIDELBERG

Sunday, July 6

12.00 m. Arrival; lunch in the Stadtgarten, inspection of the Castle, concert in the Castle Restaurant
6.00 p. m. Dinner on the Molkenkur tendered by the Board of Reception
10.00 p. m. Trip to the Castle, illuminated by fireworks, given by the City of Heidelberg
11.00 p. m. Return to Mannheim

MANNHEIM

Monday, July 7

10.00 a. m. Departure for Munich

MUNICH

Monday, July 7

5.00 p. m. Arrival in Munich
8.00 p. m. Reception of welcome in the Hofbrauhaus

Tuesday, July 8

9.30 a. m. Inspection of the German Museum and its new building
3.00 p. m. Trip to the Sternberger See
8.00 p. m. Concluding exercises in the Rathhaus

The Verein deutscher Ingenieure has extended the trip one day beyond that previously announced, making the concluding date July 8.

The Hamburg-American Line, which have charge of the outgoing trip on the S. S. Victoria Luise have been commissioned by the Committee to take complete charge also of the land trip. The entire cost of the land trip from Hamburg to Munich inclusive will be $82.

The ticket for the land tour includes transportation in second-class carriages on the trains, first-class on the steamers, lodging and breakfast (i. e., rolls and coffee) in first-class hotels. For luncheon and dinner we are for the entire trip the guests of the Verein. If any one does not participate in the excursions or functions in which these meals are included and secures them elsewhere, they must be paid for extra. If more is desired for breakfast, that will also be an extra charge.

An estimated minimum cost of the entire trip is as follows:

Outgoing voyage on S. S. Victoria Luise (minimum)	$97.50
Official trip through Germany to Munich	82.00
*Second class ticket from Munich to seaport (estimated)	11.00
Return voyage (estimated)	100.00
	$290.50

To this amount there should be added the usual fees to stewards, etc., on the ocean passage, tips in hotels, and such amounts for extra meals and service in hotels, etc., as the individual may require.

All reservations for the ocean and land trips should be made direct with the Hamburg-American Line at their New York office or at the branch offices in the following cities: San Francisco, Boston, Philadelphia, Chicago, St. Louis and Pittsburgh. No other than the above principal and branch offices may take reservations, as this is a special steamer at special rates for our party. Owing to the common desire of most American tourists to return at approximately the same time, it is almost essential that all secure their return voyage accommodations at the time of making bookings for the outgoing trip.

Formal afternoon dress, i. e., top hat, frock or cutaway coat, are expected on several occasions, and frequent evening functions will require full evening dress.

By special arrangement of the Hamburg-American Line, in addition to hand baggage, 110 pounds may be carried on the land tour free of charge; the usual amount, 165 pounds, may be carried free of charge on board ship. Any excess baggage will be charged for extra at the usual rates.

The Hamburg-American Line have cabled, in regard to the question of providing individual rooms in the hotels, that they will do their utmost to meet the request, but they cannot guarantee to do so in every case, as in some cities this will be practically impossible. Further, in most of the hotels there are available only a few rooms with bath. Any who wish such special accommodations are advised to take up the matter immediately with the New York office of the Hamburg-American Line. In this case, of course, the regular hotel charges will be made.

The Verein deutscher Ingenieure is preparing for the use of all

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* Preferable for railway travel in Germany.

participants a detailed guide-book for the trip, containing a general description of the cities to be visited and of all the industrial establishments included in the tour.

Members and guests have been duly notified through circulars issued by the Committee and the Hamburg-American Line and through the announcements in the monthly issues of The Journal and at the Annual Meeting, of the necessity of a definite decision regarding participation in the trip, either securing accommodation on the Victoria Luise, or announcing their intention to join the party in Hamburg; and the Committee feel absolved from any responsibility as to disappointments later.

Separate tickets must be secured for the land tour and it must be clearly understood that every one who goes on the steamship may not go in the official party on land.

A considerable number over the limit of 300 set by our hosts have indicated their intention of going and have requested that they be included in the official party. Members were given preference up to February 1, as had been announced, and since that date, they have been permitted to file applications for guests.

The Committee have decided that inasmuch as the option on the steamship expires March 1, and about that time our hosts must be notified of the number in our party, that from now on only those are to be regarded as members of the official party, who take reservations on the steamship or who advise the Committee definitely that they will join the party on June 19 in Hamburg, or on June 22 in Leipzig, and who will purchase their tickets in Germany.

The following is a list of those who comprise the official party to date, having either made reservations on the S. S. Victoria Luise, or intending to join the party abroad:

OFFICIAL PARTY

Adamson, Daniel
Adamson, Mrs. Daniel
Aldrich, John G.
Aldrich, Mrs. John G.
Alexander, M. W.
Armstrong, Miss Helen E.
Bates, Francis E.
Bell, James R.
Bell, Mrs. James R.
Binley, Wm., Jr.
Binley, Mrs. Wm., Jr.
Boenig, Robert W.
Bond, Geo. M.
Braun, H. H.
Braun, Mrs. H. H.
Breckenridge, L. P.
Breckenridge, Mrs. L. P.
Briggs, Leroy E.
Brinton, W. C.
Brown, R. S.
Brown, Mrs. R. S.
Bunnell, S. H.
Bunnell, Mrs. S. H.
Burleigh, P. Gray
Bursley, J. A.
Buttolph, Benj. G.
Buttolph, Mrs. Benj. G.
Christie, A. G.
Cole, F. J.
Cole, Mrs. F. J.

Conroy, R. A.
Dart, W. C.
DeBaufre, Wm. L.
DeBaufre, Mrs. Wm. L.
Dickerman, A. C.
Doble, Wm. A.
Doble, Mrs. Wm. A.
Dodge, James M.
Estabrook, M.
Easton, Miss M. E.
Eyermann, Peter
Eyermann, Mrs. Peter
Felker, Geo. F.
Fellows, E. R.
Fellows, Mrs. E. R.
Foucar, E. L.
Foucar, Mrs. E. L.
Freeman, John R.
Freeman, Mrs. John R.
French, L. G.
French, Mrs. L. G.
Fuller, Arthur A.
Fuller, Mrs. Arthur A.
Garratt, E. A.
Garratt, Mrs. E. A.
Gleason, Miss Kate
Greene, Arthur M., Jr.
Greene, Mrs. Arthur M., Jr.
Guilbert, H. M.
Guilbert, Mrs. H. M.
Hall, Carl A.
Hall, Mrs. Carl A.
Hall, James A.
Hartness, James
Hartness, Mrs. James
Heap, Douglas T.
Heap, Mrs. Douglas T.
Hersey, M. D.
Hess, H. D.
Hess, Mrs. H. D.
Jackson, A. C.
Jennings, A. L.
Jennings, Mrs. A. L.
Jessen, N. B.
Keely, R. R.
Keller, E. E.
Kent, Wm.
Klein, Arthur W.
Kothny, G. L.
LeBlond, R. K.
LeBlond, Mrs. R. K.
Leland, H. M.
Leland, Mrs. H. M.
Low, Fred R.
Low, Mrs. Fred R.
Lummis, C. W.
Macon, W. W.
Marburg, L. C.
Merriman, Mansfield
Merriman, Mrs. Mansfield
Miller, T. H.
Miller, Mrs. T. H.
Moore, Samuel L.
Moore, Mrs. Samuel L.
Moore, Miss Selma J.
Morgan, L. H.
Morgan, Mrs. L. H.
Morgan, W. F.
Morgan, Mrs. W. F.
Morse, A. H.
Morse, Mrs. A. H.
Nickel, F. F.
Nickel, Mrs. F. F.
O'Reilly, Mrs. E. R.
O'Reilly, Miss
Pennock, G. A.
Phillips, Francis C.
Plimpton, Chester H.
Reist, H. G.
Reist, Mrs. H. G.
Rice, Calvin W.
Rice, Mrs. Calvin W.
Richards, C. R.
Robeson, A. M.
Robeson, Mrs. A. M.
Roe, J. W.
Roesler, Rudolf
Saegmuller, G. N.
Sahlin, Axel
Sahlin, Mrs. Axel
Schlachter, C.
Schlachter, Mrs. C.
Schmidt, C. R.
Schmidt, Mrs. C. R.
Schmidt, E. L.
Schmidt, Mrs. F. L.
deSchweinitz, P. B.
Seligman, Walter
Seward, Miss Dora
Seward, Miss Madeline
Shaw, J. C.
Shearer, C. A.
Simon, Arthur
Simon, Mrs. Arthur
Skinner, A. C.
Smith, A. Parker
Smith, Harold B.
Smith, Mrs. Harold B.
Smith, Jesse M.
Smith, Mrs. Jesse M
Snow, Walter B.
Snow, Miss
Soverhill, H. A.
Soverhill, Mrs. H. A.
Stebbins, Theodore
Stebbins, Mrs. Theodore
Sunstrom, K. J.
Sunstrom, Mrs. K. J.
Taylor, Frank H.
Taylor, Mrs. Frank H.
Taylor, J. W.
Taylor, Mrs. J. W.
Taylor, Miss
Thorkelson, H. J.

Thorkelson, Mrs. H. J.
Thurston, E. D., Jr.
Thurston, Mrs. E. D., Jr.
deTrampe, A.
deTrampe, Countess
Trotz, J. O. E.
Trotz, Mrs. J. O. E.
Wallichs, A. O.
Wallichs, Mrs. A. O.
Walker, Charles A.
Warner, Worcester R.
Warner, Mrs. Worcester R.
Whiteford, James F.
Whiteford, Mrs. James F.
Whitlock, E. H.
Whitlock, Mrs. E. H.

UNITED ENGINEERING SOCIETY

REPORT OF TREASURER

To the Board of Trustees
United Engineering Society

I beg to submit herewith the report of your Treasurer as of December 31, 1912.

FINANCES

The Balance Sheet, submitted herewith, shows the physical property of the United Engineering Society, over and above the value of building and the equity in the land, to consist of building equipment of a value of $26,624.72, furniture and fixtures $6005, and library books $329.07.

There was added to the furniture and fixtures account during the year 1912 an amount representing an expenditure of $1383.77 including oak desk, table and chairs in library, also four large oak tables and twenty-four chairs to be used in the assembly rooms, safe for Superintendent's office, and two Edison business phonographs. In accordance with a resolution of the Board of Trustees, 10 per cent depreciation was charged off this account for the year 1912.

The principal of the mortgage on the land held by Andrew Carnegie, Esq., amounting originally to $540,000 has been reduced by payments from the Land and Building Funds of the Founder Societies to $128,000. There have been no further payments made during the year by the Founder Societies and the balances due from the societies remain the same as last year, namely, American Institute of Electrical Engineers $54,000, and American Institute of Mining Engineers $74,000. The American Society of Mechanical Engineers has paid the full amount of its indebtedness.

The gross operating expenses for the year 1912 were $47,602.71, an increase over the year 1911 of $9323.56, which is accounted for by the following unusual expenditure authorized in the minutes of the Board of Trustees: The expenditure for improving ventilating system in auditorium; storm windows fifth floor; interior painting, driveway repairs, iron fence, storm door western entrance, and re-equipping 101 thermostats (including an augmented pay roll of \$548.66) amounted to \$7910.96, the main item being \$4562.50 expended on ventilating system. An additional sum of \$2034.75 was expended in alterations, which was reimbursed by the different societies for whom the charges were made.

In accordance with a resolution of the Board at a meeting held on January 25, 1912, an appropriation of \$5000 was made out of the surplus for the year 1911, and of this amount \$4755 was invested in \$6000 Southern Railway Development and General Mortgage 4 per cent Bonds due 1956 at 79¼, as an addition to the contingency and renewal fund as provided for in the Founders Agreement, bringing the invested amount of the reserve fund up to \$25,020. It is recommended that a similar appropriation be made out of the available balance from this year's operations which will then show a balance to be added to surplus account of \$952.19.

The assessments paid for the year by the Founder Societies, each occupying an entire floor, were \$3375 (against \$4500 each for the year 1911), representing a total expenditure by each Founder Society, including interest on its full principal of mortgage on land, of \$10,575, reduced in each case to the extent the society may have paid off part or all of its mortgage share. The Associates are assessed approximately \$10,000 for equivalent facilities, which shows that the Founder Societies still meet a little more than their proportion of the carrying charges for equivalent office space occupancy in the building.

BUILDING

Equipment. The real estate equipment account during the year 1912 has been increased to an extent of \$1587, expended mainly in needed electrical work in the library.

Office Occupancy. There was on January 1, 1913, no unoccupied floor space devoted to office use in the building. There are, however, two rooms on the twelfth floor formerly used for storage purposes and now temporarily used by the library, from which no income has been received during the year.

Meetings or Lectures. The record of the number of times the rooms were used during 1912 for meetings or lectures (not for office occupancy) is:

Meeting Room		Number of Times Occupied		
		1911	1912	Change
Auditorium	3d and 4th floors	44	46	2 more
No. 1 Assembly Room	5th floor	40	39	1 less
2 Assembly Room	5th floor	54	70	16 more
3 Assembly Room	5th floor	10	33	23 more

Lecture Room No. 5	6th floor	34	35	1 more
Lecture Room No. 6	6th floor	7	0*	7 less
Lecture Room No. 8	6th floor	86	84	2 less
Small Committee Room	7th floor	26	12*	14 less
Total		301	319	18 more

* No. 6 Lecture Room is now occupied by the American Museum of Safety, and the small committee room as an office by the Aeronautical Society.

During the year 1912 the facilities of the building were enjoyed by 60 societies holding a total of 253 meetings, with an attendance of 42,324, as contrasted with 251 meetings during 1911, with an attendance of 42,400.

LIBRARY

During the year 1912 there was added to the library of the three Founder Societies and United Engineering Society, 3183 volumes and pamphlets, of which 1103 volumes and pamphlets were purchased at a cost of $3819.16. The total number of books and pamphlets in the library at the end of the year is 50,683.

The attendance during the year was 10,522 as compared with 11,014 during 1911, a slight decrease.

The department of research work has been developed as far as the present force will permit. One hundred and sixty searches have been made on a great variety of subjects in answer to requests received from correspondents in Japan, South Africa, Mexico, Canada and England, as well as from different parts of the United States, including several hundred photographic reproductions.

The library receives more than 700 technical periodicals which are available through indexes for research purposes.

Respectfully submitted,
(*Signed*) Jos. Struthers,
Treasurer

UNITED ENGINEERING SOCIETY

Balance Sheet, January 1, 1913

ASSETS

Real estate, land	$ 540,000.00
Real estate, building	1,050,000.00
Real estate, equipment	26,624.72
Furniture and fixtures	6,005.00
New York City bonds (cost) reserve	5,231.25
New York City bonds (cost) reserve	5,062.50
Baltimore & Ohio bonds (cost) reserve	5,037.50
The Delaware & Hudson Company bonds (cost) reserve	4,933.75
Southern Railway Company	4,755.00
Library Books, United Engineering Society	329.07
Library, adjustment accounts	161.58

Accounts receivable		5,035.60
Unexpired insurance		1,362.69
Cash		
Working balance	$7376.68	
For reserve fund	5000.00	
Ways and Means Committee	1165.08	
		13,541.76
Petty cash		500.00
		$1,668,580.42

LIABILITIES

Balance of land mortgage, A.I.E.E.	$54,000.00	
Balance of land mortgage, A.I.M.E.	74,000.00	
		$128,000.00
A.I.E.E. equity in building		350,000.00
A.S.M.E. equity in building		350,000.00
A.I.M.E. equity in building		350,000.00
A.I.E.E. equity in real estate equipment		3,346.61
A.S.M.E. equity in real estate equipment		3,346.62
A.I.M.E. equity in real estate equipment		3,346.62
A.I.E.E. payments to date in liquidation of mortgage on land		126,000.00
A.S.M.E. payments to date in liquidation of mortgage on land		180,000.00
A.I.M.E. payments to date in liquidation of mortgage on land		106,000.00
Depreciation and reserve fund		30,000.00
Ways and Means Committee		1,165.08
Library adjustment accounts		118.08
Accounts payable		2,024.56
Surplus account		35,232.85
		$1,668,580.42

STATEMENT OF RECEIPTS AND DISBURSEMENTS, YEAR ENDING DECEMBER 31, 1912

CASH RECEIPTS

Balance on hand, January 1, 1912	$11,308.45
Account of interest on mortgage	5,120.00
Assessment of Founder Societies	11,250.00
Assessment of Associate Societies, offices, meetings, etc	45,213.94
Notes receivable	551.00
Library account	8,114.80
Interest on bonds and deposits	1,436.33
	$82,994.52

DISBURSEMENTS

Account of interest on mortgage	$5,120.00
Account of real estate equipment	1,587.00
Operating expense, cash expenditures	45,926.39

Furniture and fixtures	1,054.33
Library account	8,114.80
Bonds purchased (reserve)	4,755.00
Accrued interest on bonds purchased	116.00
Accounts payable (from 1911)	1,113.71
A.I.M.E. office space released	858.00
Insurance	235.95
Library adjustment	432.25
Library books, U.E.S.	139.33
Balance onhand, January 1, 1913	13,541.76
	$82,994.52

Operating Income and Expenses, Year Ending December 31, 1912

INCOME

Assessment Founder Societies	$10,125.00	
Less refund for office space released	1,111.00	
		$9,014.00
Assessment Associate Societies		26,647.76
Assessment miscellaneous (offices and meetings)		8,810.75
Telephone returns		4,181.23
Miscellaneous charges to Societies		4,900.15
U.E.S. library book returns		48.45
U.E.S. library returns		63.50
Interest		1,320.33
		$54,986.17

EXPENSES

Operating expenses, gross	$47,042.10
Reserve fund	5,000.00
Insurance	917.30
Depreciation on furniture and fixtures	233.45
Balance carried to surplus account	1,793.32
	$54,986.17

JOHN FRITZ

John Fritz died at his home, Bethlehem, Pa., on February 13, 1913, in the 91st year of his age. For over sixty years he was actively engaged in the upbuilding of the iron and steel industry, that period when practically every advance in the art took place which contributed to the great engineering achievements of the present day.

There is in the possession of The American Society of Mechanical Engineers a hand-turning tool used by John Fritz when learning his trade, in place of the usual slide rest and fixed tool. In 1896, when President of the Society, Mr. Fritz in his presidential address reviewed the progress in the manufacture of iron and steel, and showed a full size drawing of the most modern type of heavy lathe of that day, weighing over 190,000 pounds. The drawing was much too long to be hung on one wall of what was then the auditorium of the Society, and in contrast with it the hand tool was shown, illustrating in a most striking manner the remarkable development in machine shop practice during the professional life of one man, and typical also of changes correspondingly great in every other department of the iron industry.

In his Autobiography, published last year, John Fritz begins the first chapter by saying, "I was born August 21, 1822, in Londonderry Township, Chester County, Pa., and was the oldest child of a family of seven children, three brothers and four sisters. I was born of parents of exemplary character, my father being a man of high moral standards; he fully impressed upon my mind the importance of absolute integrity, energy and economy. My mother was a true Christian woman . . . to my mind, the moral and religious training received from my parents was the most important training I could have possibly received; and I have ever thought the highest honor I could pay to their memory was to endeavor to follow their noble example."

His father was a millwright by trade and lived on a small farm, and John worked on the farm until sixteen years of age. This was before the days of public schools in that section and his education was obtained at district schools which kept three months in the winter and three months in the summer. The work on the farm, however, and the difficulties encountered in securing an education were but as endowments to his character which, combined with the sturdy stock of his ancestry, caused him resolutely to master the great problems of his later years. Along with these qualities which contributed to his success, were those other finer ones which made for him the many warm friendships both among his business associates and the workmen who were under him.

In 1838 he started to learn his trade as blacksmith and machinist. His most important early work was done at Norristown, Pa., where he went in 1844 to assist in building the Norristown Iron Works, and where he was soon placed in charge of all the machinery of the plant. This was a responsible position and an onerous one. There were three sets of rolls in the mill, all driven by one engine, and so much trouble was experienced with the gearing that he became hostile to all geared mills and determined that if opportunity ever offered, he would build a mill direct-driven without the use of gears. In spite of the long hours and many difficulties encountered at Norristown, young Fritz determined to become proficient in all branches of the iron industry, and regularly spent his evenings until a late hour at work at the puddling furnace and in other departments of the mill.

In 1854 Mr. Fritz went to Johnstown, Pa., as general superintendent of the Cambria Iron Works. He was employed to remodel and rebuild the plant. The mill was of such a design and was so incomplete in many ways, that he found it impossible to make the rolling of rails in the ordinary way of commercial success. He therefore asked the proprietors to build a mill according to his long-cherished plan, one with three-high rolls, direct-driven, without gearing. This proposition met with the most strenuous opposition, resulting in Mr. Fritz giving an ultimatum to the effect that this step must be taken and that he would not consent to build a geared mill. Permission was at last granted and with the introduction of the three-high system of rolling and other improvements, the Cambria Iron Works became the greatest plant of the time.

The final period of Mr. Fritz' career began in 1860 with his removal to Bethlehem, Pa., to become the general superintendent and chief engineer of the Bethlehem Iron Company, and to design and erect the company's plant. Three years later the rolling of rails was commenced and the plant was universally recognized to be remarkable in its conception and design. Here there were successive developments, which Mr. Fritz directed until his retirement. Among them were the Bessemer plant, the open-hearth process, the 125-ton steam hammer, the largest in the world, intended to produce more perfect forgings than possible with smaller hammers, the Whitworth fluid compression process with its 14,000-ton hydraulic forging press, operated by 15,000-horsepower engine and pumps, and the massive tools required for machining the forgings, and the armor plate plant for making steel plates by the Creusot process. The importance of this and similar forging plants in this country in making possible the heavy types of machinery which were constructed in the latter part of the century, such as the power units at Niagara Falls, and the large steam engines which immediately preceded the development of the steam turbine, cannot be overestimated.

Besides his active work with the various companies with which he was connected, Mr. Fritz designed for the Government a rail rolling mill erected at Chattanooga, Tenn., during the Civil War, and made plans and specifications for an armor plant for the Government, which, however, was not constructed.

Mr. Fritz received many high honors from various engineering societies and educational institutions. He was president of the American Institute of Mining Engineers in 1894, president of The American Society of Mechanical Engineers in 1896 and Honorary Member of this Society and of the American Society of Civil Engineers. He received the Bessemer gold medal of the Iron and Steel Institute of Great Britain and was elected Honorary Member of that Society. Honorary degrees were conferred on him by Columbia University, the University of Pennsylvania, Stevens Institute of Technology and Temple University.

Perhaps no greater mark of esteem has ever been bestowed on an engineer than that tendered Mr. Fritz in commemoration of his seventieth birthday. A banquet was proposed by members of the Engineers Club of New York, at first with the idea of a small affair. As the plans developed, however, 300 friends and associates sought the privilege of attendance, among whom were distinguished representatives of the Government and of many institutions and firms, necessitating the use of the Grand Opera

House at Bethlehem for the dinner. It was one of the most notable meetings in the annals of American engineering.

Ten years later, at the time of his eightieth birthday, a banquet was held in Mr. Fritz's honor at the Waldorf-Astoria in New York which also signalized the founding of the John Fritz medal by members of the four national engineering societies, a permanent fund being contributed for the annual purchase of the medal. In this way his friends have assured the perpetuation of the memory of his achievements in industrial progress.

When Lehigh University was founded in 1866, Mr. Fritz was selected as one of the original trustees and he was deeply interested in the success of the institution, as evidenced by the establishment through his generosity of the John Fritz engineering laboratory; and in his will there is provision for the further endowment of this institution.

He further made a fitting memorial to his parents in the erection at South Bethlehem of the Fritz Memorial Methodist Episcopal church and parsonage.

Of Mr. Fritz's family there survive only two sisters, a niece and three nephews. His wife died in 1908, and their only child in 1860.

The life of Mr. Fritz constitutes one of the most notable examples of an American born of poor parents and with limited education who achieved by his own personal qualities the highest success, not only in material things but in reputation and a wide circle of friends. A most interesting portrayal of his life and characteristics is afforded by the accompanying letter which we are privileged to publish through the courtesy of the Engineering News. This was written by Mr. Fritz several years ago in response to a request from Dr. W. F. M. Goss, Dean of the College of Engineering, University of Illinois, President of this Society. The letter was asked for as an inspiration to engineering students, and with the permission of Dr. Goss it has been made public.

My dear sir—Yours of Feb. 16, making inquiry in regard to my application to business, is before me. This is rather a delicate question for me to answer, as I have at all times tried to avoid notoriety as much as possible, and I request you to give what I write as little publicity as possible, consistent with the purpose you want it for, which I suppose is for an example for students who will not give their studies proper attention. I will therefore give you a very brief outline of my rule of application to business, to which I attribute my success—whatever it may have been.

I was apprenticed in the old-fashioned way, being bound out for a given number of years to learn blacksmithing and the country machine trade. In 1845 I left my home to try my fortune in the world, and went to Phoenixville in order to get work in the rolling mill, but was told that business was very dull, and that they had more men than they knew what to do with.

I there learned that a new mill was building at Norristown, and at once concluded to go there and see if I could get something to do. I went direct to the office and told the proprietors what I wanted, and was told that they had more men than they wanted; their mill was not completed, and if it were finished, times were so dull they would not start it.

I left the office, and in going back to the street, I walked through the mill and was looking at some of the machinery when one of the owners came into the mill and came up to me. I thought that he might order me out, but these thoughts were soon dispelled.

After a pleasant talk, he asked me if I was used to hard work, to which I frankly answered, "Yes." Then he wanted to know where I was raised. I told him on a farm and what I had been doing. To all of his questions I gave him a prompt answer. He then said: "Young man, I like thy looks. Will thee remain until Monday?" I replied by saying that if there was any probability of my getting employment, I would be pleased to remain over Sunday. He then said that the manager was absent, but was expected to be at the works on Monday morning, and I should call about eight or nine o'clock.

I remained over, but it was both a long and an anxious period from Saturday evening until Monday morning in a strange place. At length the appointed time came around, and I was on hand promptly. In a short time Mr. Moore, accompanied by a large, fine-looking man, came near where I was standing and halted, and had a short conversation in an undertone. To me this was a most trying ordeal, as I supposed it was to determine my fate.

After the brief conversation, they walked up to where I was standing. Mr. Moore introduced the gentleman as John Griffin, the Manager. * * * After some hesitation, I told him what I wanted. He asked what I had been doing and if I was afraid of hard work. I answered both questions in a manner that seemed satisfactory to him. He told me to come to work the next morning.

When I entered the mill the next day to go to work, I fully realized the fact that I was among entire strangers without friends or prestige, or compass to direct my course, with mind untrained for systematic work or study, and with but scant education. My thoughts naturally went back to the scenes of my boyhood days—to the old home where my kind parents and loving sisters and brothers remained. I now fully realized that I was enlisted in the army for the great battle of life, and made up my mind that I would faithfully do my duty in whatever position chance might place me, always keeping my eyes and ears open and my mouth shut. This is important. A man who is an habitual talker is an abominable nuisance about a plant, and no manager wants him.

In 1845 or 1846, then, I succeeded in getting a job—now called a situation—in the Norristown Iron Works as a country machinist, who at that day was not considered worth much. I started in at $1.25 per day, but my pay was soon raised to $1.50, that being the regular machinist rate of wages.

I was at the works with tools in hand when the bell rang. I idled no time away, and was ready and willing to do anything I was called on to do, and did it willingly, pleasantly, and with energy. The result was that when the mill was completed and put in operation, I was placed in charge of all the machinery in the plant, which to me was a great surprise.

Having previously made up my mind that the iron business would become a leading one, I was now placed in a position to get a very general knowledge of rolling-mill practice—a very important branch of it. But I soon made up my mind that to be a success, it was essential to learn all branches of it practically.

At that time puddling was the most important, the most difficult, and the most laborious of all branches of the business. But in face of all its difficulties, it was clear to my mind that I should learn it. As my time was occupied during the day, it had to be learned in off hours, which meant at night. After having my supper, I used to return to the mill and work at the puddling furnace until ten o'clock—at times later—every night, Saturday and Sunday nights excepted. This was no child's play, but I was on hand every night that the mill ran until I was well posted in the art.

About this time, there was another great surprise for me. I was called to the office without knowing what it was for, and I confess even at this late day, I well remember that as I had never been sent for before, I went to the office with some fear that they were in some way dissatisfied with me. When I entered, I found both partners in their private room and both of them seemed in a pleasant mood.

Now this is especially for your boys, and they should commit it to memory and ever have it in mind.

Mr. Moore, the senior partner, said that the man (calling him by name) who had charge of the mill in the night time, was not giving satisfaction, and they had dismissed him and wanted me to take his place. I was amazed for a moment. After gathering myself together again I said to them: "I do not want the position, and if I did, there are four other men (naming them) that are older than I and have been with you longer than I have." Two of them were nephews of Mr. Moore, and the other two were friends of both Mr. Moore and Mr. Hoover, the proprietors of the works.

Mr. Moore, who was the spokesman and a friend, said: "John, if I were going to look for thee any time after thee got thy supper till ten or eleven o'clock, I should come to the mill; if for either of the others, I should look over the town, and we insist upon thee accepting the position. To us, it is very important to have a person there at night that we have full confidence in."

Consequently I accepted, though reluctantly, as I was fearful that it might in a measure interfere with my opportunity of gaining practical knowledge of the manufacture of iron. Fortunately, I had gained a good knowledge of the art of puddling, which to learn properly made it necessary to be at the furnace from the time the heat was charged until the metal was finished, taken out and rolled, which required some two hours.

In learning to puddle, I acquired the skill necessary to work a furnace properly, which assisted me very much in becoming a heater. Learning to roll was not at all difficult, for being a blacksmith, handling the tongs came naturally, besides I was not confined to any given length of time. I could take the tongs and roll for five minutes, more or less, as the opportunity occurred. But getting up the templates for the rolls at that time was quite another matter. Having but little experience and no books on the subjects, at least none that we knew of, we had to think them over thoroughly and experiment with them until they would work all right.

Having now graduated in all the branches in the mill, in the manufacture of bar iron, pipe iron, boiler plate, tank iron, band iron, nails, car axles, shafting, heavy rounds and squares, and about all kinds and sizes of iron that were there being manufactured, I concluded that the rail business, although in a most deplorable condition at that time, would eventually become a leading branch of the iron business, and made up my mind that it would be important to know something about that.

At this time there was a rail mill going to be built at Safe Harbor, near Lancaster, Pennsylvania, and the owners wanted me to go there to erect the machinery in the mill. This was just what I wanted to do. At once I had a talk on the subject with Mr. Moore and Mr. Hoover, * * * and they finally consented to let me go.

When I left Norristown, I went directly to Safe Harbor and put the machinery in place, and remained there some two years, being finally driven away by fever and ague. I then returned to Norristown to my old place.

When Mr. Reeves learned that I had left Safe Harbor, he sent for me to come and see him, and he wanted me to go to Phoenixville and take charge of the machinery and shops there * * * .

I then had a private talk with Mr. Moore, saying to him that I had now had practical experience in all branches of the manufacture of iron except the work of the blast furnace, which is the first of all, and that I could not be a thorough, practical ironmaster without having a practical knowledge of the blast furnace. He said that the view which I took was quite correct, and consented to let me go after some work that I had on hand was completed; after that was finished he said he would be satisfied to let me go, and to this arrangement Mr. Hoover subsequently agreed.

I now took hold of the project of remodeling and rebuilding the furnace and getting it in blast. This was accomplished with complete success, and I remained with Mr. Reeves about two years. I then returned to Messrs. Moore and Hoover to make some improvements in their mill.

Having obtained a very general knowledge of the iron business, both in the mechanical and practical working of the same, and also in the conversion of pig iron to wrought, and putting it in shape for the market, I, in company with others, put up a foundry and machine shop, with the view of remodeling and building blast-furnace and rolling-mill machinery.

Before the shops were completed, Mr. David Reeves, in company with a few others, leased the Cambria Works at Johnstown, Pennsylvania, and insisted on my taking the position of general superintendent; and he having strong claims on me, I accepted the position—whether wisely or unwisely I have never been able to determine.

The plant was new, yet it was not possible to make a commercial success with it without many changes and betterments, which involved the remodeling and rebuilding of the whole plant. This I did, and at the expiration of six years of the most strenuous labor, I left the works with their acknowledged supremacy as the best rolling-mill plant in the world.

On the morning of July 5, 1860, I bade Cambria Iron Works people goodbye and arrived in Bethlehem the same evening; and on the morning of the sixth, I entered the employ of the Bethlehem Iron Co. and built the iron and steel plant, and later on erected the hydraulic forging plant, the machine shop, and the armor-plate plant and finishing shop.

Now a word about application to business. It has been my rule through life to be at the works every morning, Sundays excepted, winter and summer, at half past six, breakfast being over before I leave the house.

This gives me time, if anything has gone wrong in the night, to make arrangements for the repair men to go directly to whatever place they are needed, and to see that all the men are in their places. It is always better to say "Come boys" than "Go boys," and an hour in the morning is worth more than two in the afternoon.

At half past eleven, some of the principal foremen go to their dinner, and about half past twelve they return. Then I go to my dinner and return about two o'clock. I get my supper about half past six and return to the works at half past seven and remain until half past nine; then I go home and go to bed at ten o'clock sharp, unless something is going wrong at the works, and then I know no hours until it is righted.

One Monday morning about one o'clock, we had not finished what were called "Sunday repairs," and * * * I was waiting for the job to come back. * * * I noticed an Irishman standing leaning on his shovel, looking at me. After a little while he walked over to where I was standing and said to me: "Mr. Fritz, I was standing looking and thinking and wondering how long you have been in an iron works." I said to him: "Some thirty-odd years." He said, "I have been with you nineteen years, and you have been making time and half time ever since I have been with you."

I write this to show that men do not often hurt themselves by hard work and long hours if they take proper care of themselves.

Outside of fever and ague, typhoid fever, pneumonia, and an attack of erysipelas, the time I was away from the works on account of sickness would not average over one day in a year. This seems remarkable, as I was exposed to all kinds of temperatures—going from the hot furnaces out in to the cold in winter, when the thermometer was down to ten. No matter how badly it stormed, I was at the works attending to my duties, and rarely took a cold.

My first work in the iron line was in 1838 at a charcoal furnace which made about 16 tons per week; the total production that year in the United States was 263,000 tons. This year (1905), at the rate it is now going, it is supposed that the production will exceed 20,000,000 tons.

I have not only been contemporary with the marvelous improvements that have taken place in the iron and steel industry, but have had much to do with their introduction and perfection.

In regard to the fifteen years you refer to, when I was building the Bethlehem gun-forging and armor-plate plant, one thing I did was to go abroad to see what they were doing on the other side of the water. I saw most of the large iron and steel and forging plants in England, Germany, Belgium and France, and was absent from home only about six weeks; and I think it was about the hardest work I ever did, except the building, organizing and getting the works started and the steel to stand the high physical test required by the government for the gun forgings and armor-plate.

It was my rule to make my own foremen, selecting them out of the men employed in the works, but when we came to select men to do work they had never seen, it was something of a task; but it was done and not one of the men selected to take charge had ever seen a plant for doing the kind of work he was called on to do.

The best and hardest and most difficult work of my life was done when I was between 65 and 73 years of age, yet many well-minded people are under the impression that men over 45 are quite useless. They seem to forget the fact that experience counts for much. An experienced man does his work better, faster and easier for himself and those around him than a novice, although a much younger man. A man with experience has confidence in himself, knows what he is doing, and does not hesitate. He goes ahead with the assurance that he is right.

My life has been an active one in the most laborious, exacting and important branch of manufacture in the domain of human activities, requiring courage, endurance, and a most varied talent. In August next (1906), I shall be 83 years old, and I am now hearty and active, both mentally and physically, and do not think that I am yet a proper subject for chloroform.

As representatives of the Society the Council appointed the following Honorary Vice-Presidents to attend the funeral of John Fritz at Bethlehem on February 19: Frederick R. Hutton, Jesse M. Smith, H. G. Stott, Alfred Noble, Calvin W. Rice, John R. Freeman, John A. Brashear, Henry R. Towne. These, with about twenty friends from the Engineers Club, the American Institute of Mining Engineers and the John Fritz Board of Award, went on a special train from New York. There was a large attendance of the immediate family and friends, and hundreds of people of the city in which Mr. Fritz had lived for so many years were grouped about the house and on the street at the time of the service. The entire company followed the body to the cemetery where the simple service of the Moravian Church was conducted.

BALTIMORE HIGH-PRESSURE FIRE SERVICE

By James B. Scott

ABSTRACT OF PAPER

The Baltimore high-pressure fire service, recently placed in operation, has several features which are departures from the design of similar systems in other cities.

For reducing the time element in reaching the scene of a fire the department is provided with high-speed automobile hose wagons, equipped with monitor nozzles, 3-in. hose and portable hydrant heads.

The hydrant heads are fitted with four permanently attached combination operating and regulating valves. By the movement of a small lever the pressure on each hose line may be independently regulated to any desired amount from complete shut-off to full hydrant pressure.

Flush hydrants are used, provided with bayonet joints for quickly attaching the portable heads. Hydrants are alternated on opposite sides of the streets and are generally located in the center of the sidewalks, to give an unobstructed sweep of the streets longitudinally, forming a water curtain in front of exposed property.

The gridiron is of lap-welded, rolled steel pipe with metal to metal universal joints. The electrical resistance of the joint is low, and by the use of a heavy asphalt coating, the rapid deterioration due to electrolytic action has been avoided. Branches are attached through welded necks. All valve bodies and specials are of cast steel. Leakage is almost nothing.

Steam driven crank and flywheel plunger pumping engines are used, provided with automatic speed and pressure regulators.

Boilers are covered with an air-tight steel plate housing, to reduce radiation losses during standby service. Coal burning furnaces are installed, with forced draft and mechanical stokers, having automatic control of air and fuel. Coal is supplied by gravity to the stoker hoppers from overhead bunkers. Feedwater regulators are included, with governors on the feed pumps. The station building is entirely fireproof, and if the crew should be driven out by a conflagration, the station could operate automatically for several hours.

Simplicity and reliability have been placed foremost in the design. The station possesses a large overload capacity beyond its rating. The total operating expenses and fixed charges are lower than with electrically operated pumps.

BALTIMORE HIGH-PRESSURE FIRE SERVICE

By James B. Scott, Baltimore, Md.

Member of the Society

The Conflagration of 1904.—The conflagration of 1904 was due to the simultaneous occurrence of an incipient warehouse fire gaining headway unobserved on a Sunday morning; a high wind; inferior building construction and inadequate fire fighting equipment.

2 During the first eight hours of the fire the wind was blowing from the southwest, after which it shifted 90 deg. to the northwest, causing the fire to advance with its broadside of 1500 ft. for a front. Although supplemented by engines from other cities, after the fire had got beyond control the operations of the department might be described as a skillful retreat, an engine and a truck being lost under falling walls because the retreat had not been sufficiently rapid. Dynamite was freely used by skillful operators, but was practically ineffective. The fire raged for 30 hours, covering 150 acres, causing a loss of $100,000,000 and finally burned itself out when the wind changed again to the north and drove the flames toward the open harbor.

3 There was no scarcity of the water supply. The topography of Baltimore shows elevations ranging from 6 to 460 ft. above mean low tide, and to prevent excessive pressures in the low lying sections or a deficiency in those higher up, the supply is divided into five separate services. The "low" and "middle" services are fed entirely by gravity, the three higher services being supplied by pumps and high storage reservoirs. Suitable by-passes are provided so that in an emergency any service can be supplied from the next higher. At the time of the conflagration there was available a total reservoir capacity of over 1,750,000,000 gal., in addition to pumps of 63,000,000 gal. capacity. At that time the consumption for domestic and industrial purposes was about 60,000,000 gal. daily, and the draft

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

from the reservoirs for fighting the conflagration was approximately the same amount, or a trifle over 3 per cent of the available reservoir capacity. In addition to the reservoir draft, about two hours after the fire started the two 17,500,000-gal. pumps in one of the high-service pumping stations were by-passed into the "middle" or upper gravity service. The fire originated in the middle service district and shortly afterward extended into the low service district. As soon as this occurred the by-pass between the two was opened, and the pressure was maintained at 80 lb. during the remainder of the fire.

4 The operations against the conflagration demonstrated that, for effective fighting of a dangerous fire, large volumes of water must be delivered on the fire with the least possible delay, and at suitable pressures. To meet these requirements a separate high-pressure fire service was designed and installed, covering the greater portion of the congested value districts of the city.

5 *Characteristics of the Congested Value Districts.*—The corporate limits of Baltimore embrace an area of 31½ sq. m., with a density of population of 17,729 per sq. m., a density greater than any other of the larger American cities. The congested value districts cover approximately 300 acres, the area at present covered by the high-pressure mains is about 175 acres, or assuming that the territory for 200 ft. outside the mains is protected, the high-pressure district may be considered to be 245 acres.

6 The elevations of the congested value districts vary from 6 ft. to 100 ft. above mean low tide, about one half of the area being below elevation 50. The pump centers at the high-pressure station are at about elevation 12.5.

7 The character of the building construction in the congested value districts varies from first-class modern fireproof structures to converted residences, except in the rebuilt burned district, where a better type of construction exists. In the districts in question all electric wires have been placed underground in conduits owned by the city, with the exception of the street railway trolleys. Before rebuilding the burned district, several narrow and congested streets were widened and plazas established around important public buildings, so that the conflagration hazard in that section has been considerably decreased.

DESIGN OF THE HIGH-PRESSURE SYSTEM

8 *The Time Element.*—High-speed automobile hose wagons are provided, housed at convenient locations, in order that the minimum

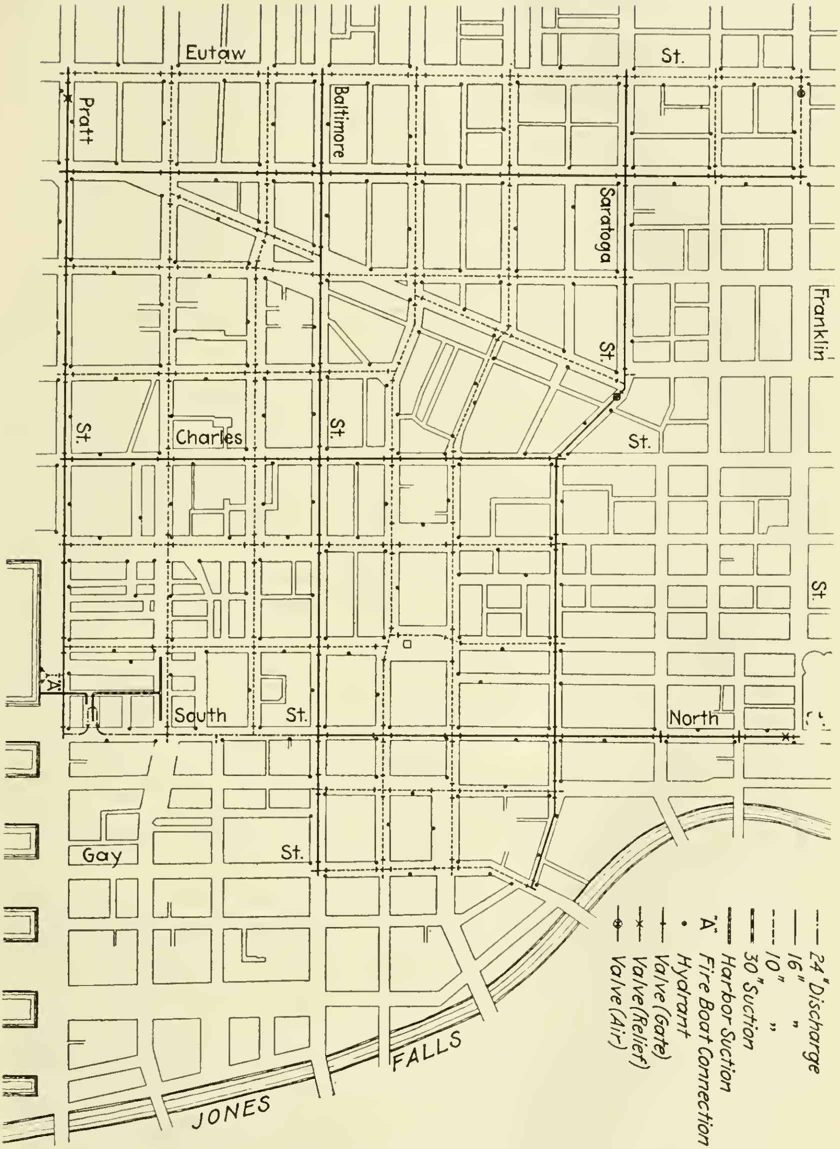


Fig. 1 Map of the High-Pressure District

time possible may be consumed in reaching the scene of a fire after the alarm is received. Each wagon is equipped with a four-cylinder four-cycle motor of sufficient power to develop a speed of 30 m. an hr. through the streets of the city, with a load of 5000 lb. Each body is 50 in. by 34 in. by 12 ft. inside, and carries 2000 ft. of 3-in. hose. Each body is equipped with one 2000-gal. Morse Invincible monitor nozzle and two 1100 gal. monitors.

9 *The Pressure Element.*—The pressure required for effective work varies widely according as conditions demand the flooding out of a basement fire or fighting on the top floor of a modern skyscraper. At times both extremes may be required simultaneously.

10 To meet efficiently these conditions requires the maximum pressure to be available at each hydrant, with means for the separate control of the pressure on each hose line. The specifications called for a combination operating valve and regulator capable of adjustment from shut-off to 50, 75, 100, 125, or 150 lb., or if desired, to the full line pressure of 300 lb. The pressures were to be plainly marked on the valve by notches to be used by the operator as a guide for setting the handle. Regulators were to hold the pressures steadily within 10 lb. of the set amount, whether the play pipe were open or closed. The regulator was also to be provided with a lock whereby the handle could be prevented from passing the 150 lb. notch, but after unlocking could be moved to the full line position. When wide open under the maximum pressure of 300 lb. the valve was not to show a loss of head in excess of 15 lb. The hydrant head was to contain four horizontal outlets and one vertical outlet, each horizontal outlet to be provided with a regulator, and the complete head including four regulators was not to weigh over 110 lb. The head and regulators were to be designed for 300 lb. working pressure and were to be tested with a static pressure of 600 lb.

11 While the above requirements may seem simple enough, only one of the valves submitted by different makers met the requirements in all essential points, a regulator designed especially for the purpose by the Ross Valve Mfg. Co. of Troy, N. Y. (Figs. 2 and 3.)

12 The main regulating valve is inserted in an opening just over the hose connection, and is inclined outward at an angle of 20 deg. The opening is closed with a plate carrying a pilot valve and a guide for the main valve. The pilot valve with its diaphragm is covered with a spring chamber, the whole being held in place by cap screws. The main valve is balanced and is provided with a flat seat and leather face. The upper part of the main valve acts as an operating

piston, being provided with a cup leather packing. The pilot valve is balanced against the delivery pressure by the regulator springs, which are made double to secure a wide range of pressure in a short length. The top of the spring chamber is revolved by the operating handle attached to it, and being provided with a coarse square thread screw, less than one revolution is sufficient to give the full range of pressure on the springs from full open to closed. The pilot valve is held positively in the two extreme positions independently of the springs by stops at the top and bottom of the stem. The full hydrant pressure is admitted to the operating chamber of the main valve through a small tube projecting below the seat of the valve. This tube is extended in order to keep the entrance clear of the varying velocity near the valve seat, which would tend to vary the flow of water to the operating chamber. When the pilot valve is open, water wastes from the operating chamber, the pressure is lowered and the main valve is opened by the unbalanced pressure below. When the pilot valve is closed the full hydrant pressure is maintained in the operating chamber, and as the area of the operating piston is somewhat larger than the area of the main valve, the pressure is unbalanced in the opposite direction and the main valve is closed. Intermediate positions of the pilot valve are followed by corresponding movements of the main valve, maintaining the delivery pressure within a few pounds of the amount indicated by the notch at which the operating handle is set. The main valve when fully opened presents an unobstructed waterway. The entire mechanism is simple in design, easy to operate and has proved entirely satisfactory in service.

13 *Quantity of Water Available.*—The National Board of Fire Underwriters after a careful study of the situation recommended that a total delivery of 15,000 gal. per min. should be available within any area not exceeding 100,000 sq. ft., at a pressure of not less than 200 lb. at the hydrant. As installed, each hydrant has four $2\frac{1}{2}$-in. horizontal and one vertical outlet for mounting a monitor nozzle. At present the 3-in. hose is connected through reducer couplings, but in the future all hydrants will be equipped with 3-in. outlets and connections to $2\frac{1}{2}$-in. hose will be made through reducers.

14 The quantity of water which can be delivered through a hydrant is a function of the number, length and size of hose lines attached, and the diameter and type of nozzles. Assuming four lines of 3-in. rubber-lined hose each 100 ft. in length, and 200 lb. at the hydrant, with $1\frac{3}{4}$-in. smooth nozzles, each hydrant would de-

liver 3800 gal. per min., or the requirement of the underwriters would be met by four hydrants. At least twice that number of hydrants are available for every unit of area mentioned. If 2-in. nozzles were used, other conditions remaining the same, the discharge would be 4400 gal. per min. at a pressure of 86 lb. at the base of the play pipe, as compared with 108 lb. in the former case.

15 At present 226 hydrants have been installed, staggered on opposite sides of the streets, averaging about 170 ft. lineal spacing. In addition to the normal locations at street and alley intersections, the fire chief placed a number of hydrants at special positions, to meet local conditions of exposure, extra hazard or specially congested values.

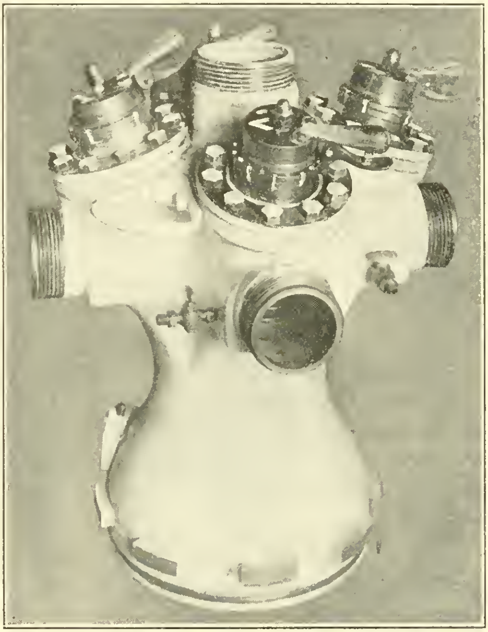


Fig. 2 Portable Head

16 *Design of Hydrant.*—The type of hydrant to be used was given careful study. It was considered especially desirable in view of the experience gained in fighting the conflagration, to be able to place a monitor or special flat nozzle directly on the top of the hydrant, to form a water curtain for the protection of exposed property on the opposite side of the street. Street intersections form a

specially desirable location for such a purpose, but usually the corner of the footway is preëmpted for various other structures such as sewer inlets, lamp posts, trolley poles, police and fire-alarm boxes, etc. It was soon evident that if restricted to the ordinary post type of hydrant, it would be impossible to secure suitable locations, and the water-curtain feature would have to be abandoned. The flush hydrant with portable head seemed to meet all the conditions admirably. By the use of this type, hydrants could be located almost without restrictions, either in the driveway or any part of the footway. The portable head was also admirably adapted to the use of the regulating valves on the hydrant, as the entire operating mechanism, other than the main valve, could be kept in the firemen's

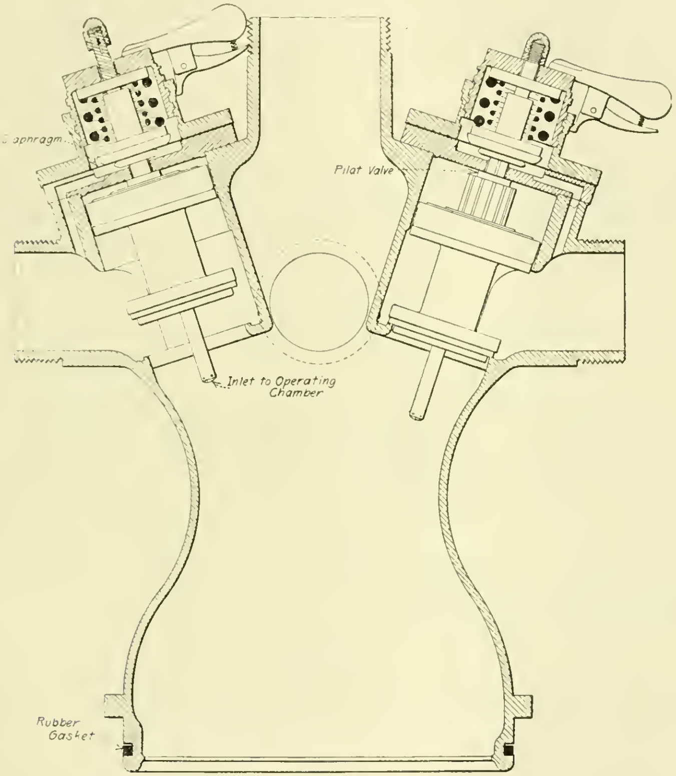


Fig. 3 Section of Portable Head

quarters, instead of being exposed to frost or other injuries on the street.

17 The portable head as designed, complete with four regulating valves, weighs 110 lb. In order to provide against any delay in attaching the head to the hydrant, a special "bayonet" joint was designed (Fig. 2). The head slips loosely into the barrel of the hydrant, and by a twist of $22\frac{1}{2}$ deg., a series of interlocking lugs on the head and barrel engage each other, and the full section of these bronze lugs is in shear to resist the water pressure. The water joint is made by means of a square soft rubber packing ring placed in a square groove on the outside of the lower portion of the head. The groove is somewhat larger than the packing ring, and at very low pressures water leaks past the ring. At higher pressures, however, the water presses the rubber closely against the barrel, and the joint is absolutely tight at all pressures between 20 and 1000 lb. The action is entirely automatic, there being no screws nor glands of any kind to be manipulated. When the water is shut off, the ring contracts and the head can then be lifted out of the barrel without the slightest resistance. To illustrate the extreme simplicity of the device, and the ease of handling, a recent test by the engineers of the National Board of Fire Underwriters may be cited. The head and operating key were laid in the center of the street, 20 ft. away from the hydrant. Two firemen selected at random, picked up the head and key, ran to the hydrant, removed the two loose covers, placed the head in position and turned the water on, all in the space of 18 seconds by a stop watch.

18 A small cast-iron cover is laid over the top of the barrel to protect it from dirt and injury, and over this is placed a larger cast-iron cover flush with the pavement. As practically all the hydrants are located on the sidewalks the cover is made quite light, and if it should become frozen in, it can be broken instantly by a blow from the operating key.

19 The hydrant proper is designed for a clear waterway of 28 sq. in. through the main valve. The main valve closes with the pressure, and an auxiliary is provided, actuated by the main valve stem. This auxiliary valve opens in advance of and equalizes the pressure before the main valve starts to open. A drip valve is arranged so that as the main valve opens the drip is closed and vice versa, but both valves cannot be open at the same time. Both the main and auxiliary valves have conical leather faces and bronze seats. The

barrel of the hydrant is of soft grey iron, and all nuts and fittings, stuffing-boxes, etc., are of bronze. The main valve stem is Tobin bronze, and the operating spindle is of forged steel. All pressure parts are designed for a working pressure of 300 lbs. with a factor of safety of twelve. After erection a field test of 600 lbs. was made.

HIGH-PRESSURE PIPE LINES

20 *General Plan.*—The general plan of the system is a gridiron of 16-in. mains crossing at intervals of approximately 1200 ft. in each direction, with 10-in. laterals in the intermediate streets spaced approximately 400 ft. apart. A 10-in. branch is provided at the harbor front for connection with the fireboats (Fig. 4). All hydrant

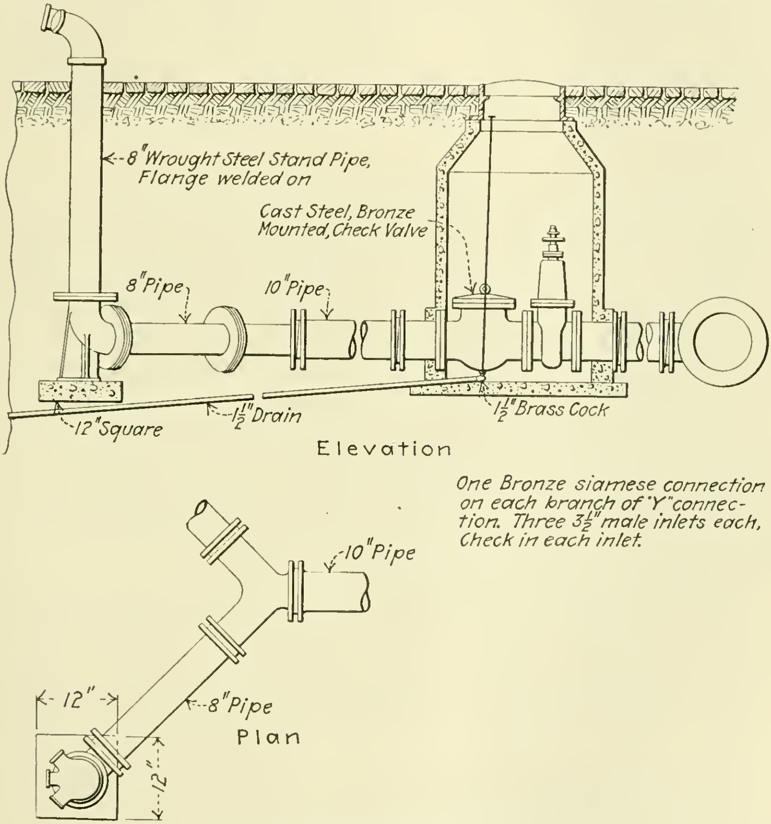

8" Wrought Steel Stand Pipe, Flange welded on
Cast Steel, Bronze Mounted, Check Valve
8" Pipe
10" Pipe
$1\frac{1}{2}$" Drain
12" Square
$1\frac{1}{2}$" Brass Cock
Elevation
One Bronze siamese connection on each branch of "Y" connection. Three $3\frac{1}{2}$" male inlets each, Check in each inlet.
10" Pipe
8" Pipe
12"
12"
Plan

Fig. 4 Fireboat Connection

branches are 8 in. There are no dead ends on mains or laterals in the entire system, with the exception of an extension on one street which will be connected up at the next addition to the system. From the pumping station two 24-in. mains discharge into the intersections of the 16-in. mains. In the pumping station the 24-in. mains are looped around the rear of the pump foundations, thereby avoiding dead ends and by equalizing the stresses render unnecessary any heavy anchorages. Individual 14-in. pump discharges deliver directly into the 24-in. mains through welded necks. Three 24-in. valves and an 18-in. cross connection in the station, serve to sectionalize the large main, so that any portion may be cut out without putting more than one pump out of commission. A large rolled steel air chamber 30 in. in diameter by 20 ft. high is placed on each 24-in. discharge main.

21 *Cast-Iron versus Steel Pipe.*—For the service in view it was believed that cast-iron pipe, usually employed for city water mains, was not a scientific application of material for the stresses involved. On the other hand, commercial rolled steel lap-welded pipe meets the structural conditions much more satisfactorily. With this material the pipe system becomes an engineering structure, all tensile and bending stresses are taken up by the pipes themselves and the system would be entirely safe if laid on the surface of the ground.

22 The principal objection urged against the use of steel for this purpose is the liability to corrosion, especially when complicated by electrolysis in city streets. After a careful study of the problem, it was decided that the advantages of this material outweighed the objections, for the following reasons:

a If the entire pipe system had to be renewed every ten years, the steel would still be more reliable and hence more desirable than cast iron, as the latter is liable to fail by breakage without previous warning. When deterioration of the steel pipe does occur, it makes itself known by increase of leakage, which can be detected and repairs made gradually, as occasion offers. By way of reductio ad absurdum it might be argued that if absence of corrosion be the controlling feature in the selection of a material, a glass pipe would be the ideal, as it would last forever if not broken by shock or bending stresses.

b The study of corrosion of steel has reached a point where it is possible to say that corrosion is not inevitable, but is due to more or less direct violation of certain well defined principles. If steel can be protected from the simultaneous action of moisture, air and acids, the causes of rusting or corrosion are to a great degree removed, regardless of the particular chemical theory held by the investigator. Protecting the steel from the action of these three agents is mainly a mechanical proceeding. A permanent, impervious, elastic coating, which will adhere closely to the metal is the requirement. High-grade asphalt applied when both the steel and the coating are hot and clean, seems to meet these conditions satisfactorily. The specifications for the chemical composition of the asphalt used were very exacting. Among other conditions it was required that a cubic centimeter of the material should show no action when exposed for one year in any or all of the following solutions: 25 per cent hydrochloric acid, 25 per cent sulphuric acid, 25 per cent potassium cyanide, 25 per cent caustic soda, saturated solution of ammonia. The pipes were thoroughly cleaned and heated to a temperature of 300 deg. fahr. and while hot were dipped vertically in the bath of asphalt, which was maintained at a temperature of from 350 to 400 deg. fahr. The pipe was held in the bath for a sufficient length of time and was then drawn out slowly, at the rate of 5 to 10 ft. per min., so that a coating of 1-32 in. thickness was evenly distributed over the entire surface of the pipe. Any damage to the coating during shipment or erection was repaired by the application of the same material dissolved in a suitable solvent, and applied in several coats at intervals, until a satisfactory thickness was obtained. All bolts and nuts were dipped in the same solution before being inserted in the flanges.

c Electrolysis is due to an electrical difference of potential between the metal and the earth in contact with it, of sufficient magnitude to cause a current flow from the pipe to the earth. Since the conflagration of 1904 the City of Baltimore has required all electrical wires to be placed in the municipal conduits, and to protect the cables from electrolytic action the city's electrical commission made a careful study of the local situation. As a result the street railway was compelled to rebond a large part of its tracks, copper cables being carried around all special work. In addition a supplementary copper return covering the entire district was installed, consisting of three bare copper cables having an aggregate cross-section of 6,000,000 circular mils. An entirely separate copper return was also installed as a protection for the cable sheaths, nothing but lead cables being bonded to this. The cross-section of this latter varied from 1,000,000 to 6,000,000 circular mils. As a result of this large amount of copper in the return circuit, the difference of potential between the various underground structures has been reduced to a nominal figure.

The special joint designed for the Baltimore Steel pipe line has a resistance equal to 6 in. of the pipe on the 10-in. size, and equal to 9 in. on the 16-in. pipe. The resistance of a bell and spigot lead joint is often equal to 4 or 5 ft. of the pipe.

d Finally, the current flow from the pipe to the earth may be made very small if a high resistance covering be placed around the entire pipe system. In the present instance the asphalt coating furnishes the necessary high resistance envelope.

23 While it is still too early to offer definite evidence regarding the life of the pipe in question, pipes which have been in the ground for two years have recently been exposed by excavations for other work, and have shown absolutely no signs of deterioration, the coating being in perfect condition.

24 *Pipe.*—The specifications called for lap-welded pipe made of soft open hearth steel having the following qualities:

	Per Cent
Carbon, not exceeding	0.10
Phosphorus, not exceeding	0.04
Sulphur, not exceeding	0.05
Manganese between	0.35–0.45

Ultimate tensile strength between 50,000 and 55,000 lb. per sq. in.; elastic limit at least ½ ultimate; elongation not less than 20 per cent in 8 in.; cold and quench bend 180 deg. flat.

25 The weld in the lap was to be perfect and capable of standing the strains incident to the manufacture of bends and forming of joints, without distress or rupture.

26 The thickness of pipe, in inches, was as follows:

24 in. Outside Diameter	½
16 in. Outside Diameter	$\frac{7}{16}$
10 in. Inside Diameter	$\frac{7}{16}$
8 in. Inside Diameter	$\frac{7}{16}$

27 Bends were generally of a standard radius of 5 diameters of pipe. Length of pipe, in feet, laid was:

24 in.	1,275
16 in.	17,052
10 in.	28,229
8 in.	7,137
Total	53,693 = 10.2 miles

28 *Joints.*—For the present service it was desired to avoid the use of rubber gaskets, which would tend to increase the electrical resistance of the joint. Copper gaskets or other metals dissimilar to the metal of the pipes, in the presence of moisture and the acids or salts of the earth, would form a voltaic cell, and tend to increase the corrosion due to electrical action. A joint was therefore designed to avoid altogether the necessity for a gasket or joint cement of any kind.

29 The Baltimore design is a form of universal joint (Fig. 5). The end of the pipe is flanged out into a bell forming a zone of a sphere. A soft cast-iron ring is accurately turned in the shape of a torus, having the same curvature on its exterior surfaces as the interior of the bell on the pipe ends. Loose flanges are placed on the pipe back of the bell, and when bolted up, draw the pipe bells up on the torus ring (Fig. 6). The pressure secured by the wedging effect on the spherical surfaces is enormous. If the curve of the surfaces be too flat, the metal of the pipe may be cold rolled, and the flanges may be pulled over the ring. By suiting the degree of the curvature to the diameter of the pipe, a safe combination is secured, and with the proper thickness of loose flange, a joint is secured which is absolutely water tight until pressures are reached which exceed the elastic limit of the pipe or bolts. On the 10-in. size this pressure is about 2200 lb. per sq. in. In the field testing, during the installation of the pipe, the specified test pressure was 600 lb., but during the early stages of the work, this pressure was often largely exceeded.

30 The joints are designed for a deflection of 10 deg., or about 3 ft. 6 in. in a 20-ft. length. On the 10-in. size this amount of deflection is easily obtainable, but on the larger sizes a smaller amount was used, though sufficient to be of considerable value in city work. A line of 10-in. pipe was made up of seven 20-ft. lengths, and while the pressure was on, one end of the line was raised 5 ft. by means of a crane, as shown in Fig. 7. While suspended in the air, supported only at the two ends, 140 ft. apart, there was practically no leakage at any of the joints. It is evident that at least that amount of trench might be washed out without interfering with the operation of the pipe system in the least degree. In laying the pipe it was possible to deflect it to pass an obstruction and in one instance, after the com-

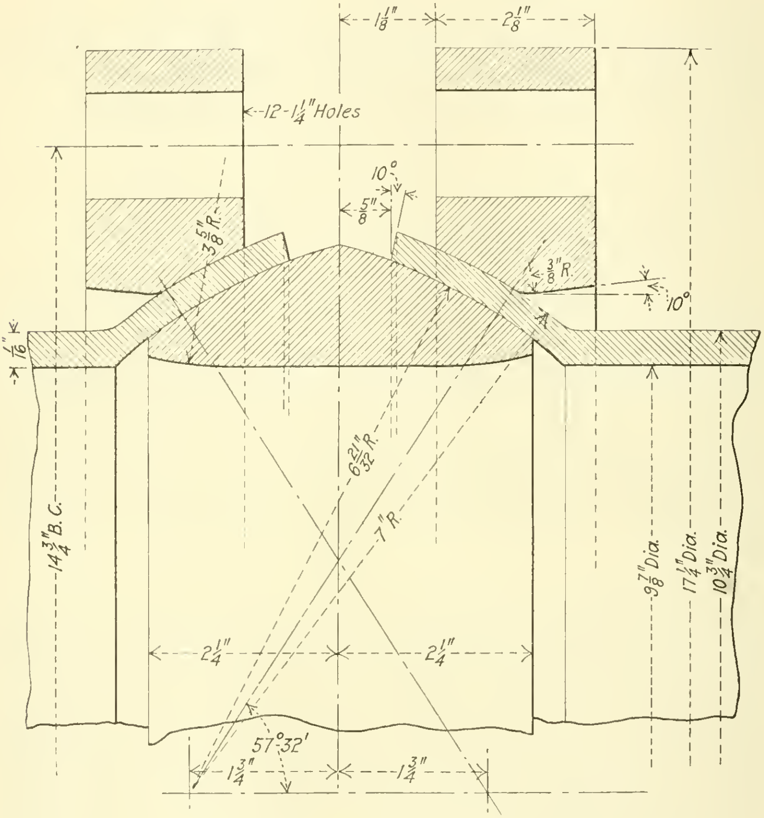


Fig. 5 Detail of 10-In. Pipe Joint

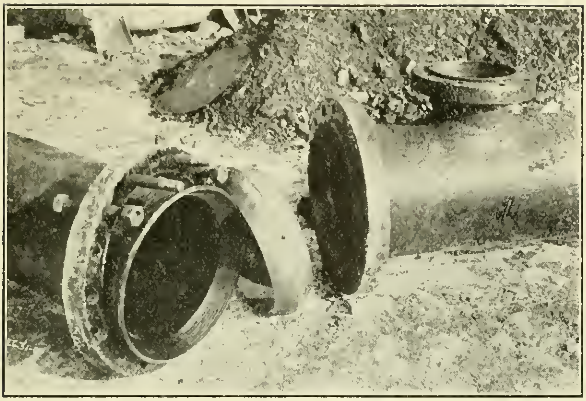


Fig. 6 View of Pipe Joint and Welded Neck

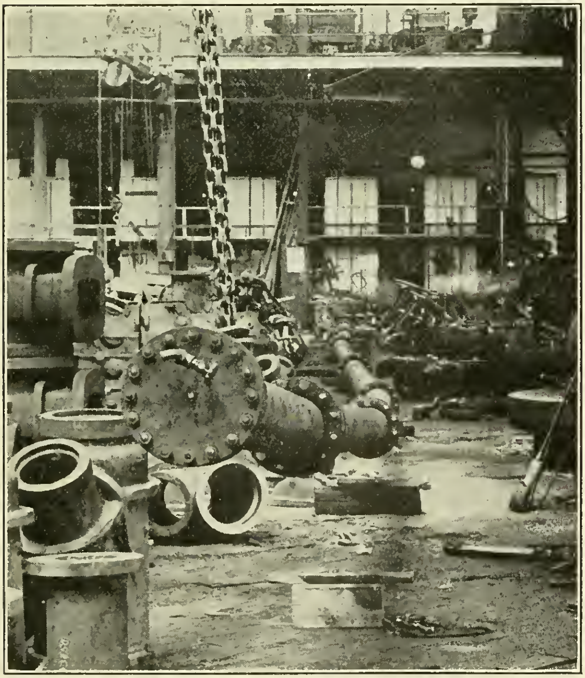


Fig. 7 Shop Test of Pipe Joint

pletion of the work, owing to a change of grade in the sidewalk, a hydrant branch 50 ft. long was jacked up 5 in. at one end, simply by loosening the bolts at one joint. Upon tightening these bolts, the line tested free of leaks at 600 lb.

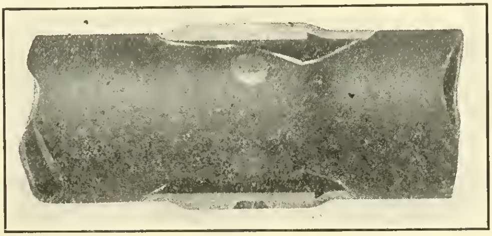


Fig. 8 Detail of Straight Line Weld

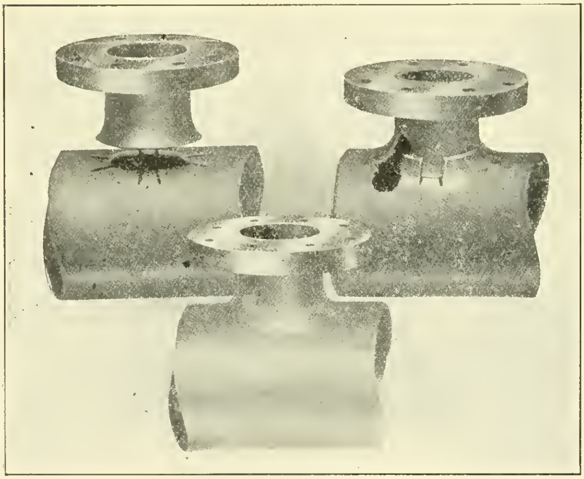


Fig. 9 Detail of Welded Neck

31 The fact that the pipe was laid in 20-ft. lengths means that the number of joints was reduced 40 per cent in comparison with cast iron.

32 For deflections greater than could conveniently be made by the joints, pipe bends were used. A bending table was installed on the work by the contractor, and about 1500 bends were made, or 150 per mile of pipe laid. Bends of 16-in. pipe and smaller were made

on the work, the 24-in. bends were made at the factory before shipment.

33 For make-up pieces at intersections and in blocks between valves or tees already installed, straight line welded joints were used. A special joint was devised for this service, made up as follows: The end of one pipe was accurately expanded sufficiently to permit of its being shrunk over the end of the pipe to which it was to be joined. Holes were cut around the circumference of the outer pipe or bell, and after being heated it was shrunk on in place. The holes were then flowed up with metal by the oxy-acetylene blowpipe, and the end of the bell was also welded to the enclosed pipe. With this type of joint the weld is in shear and not in tension, and it is entirely feasible to make bends in the pipe with the weld in the arc of the curve. Approximately 1500 of these straight line welds were made on the work, or about 150 per mile of pipe (Fig. 8).

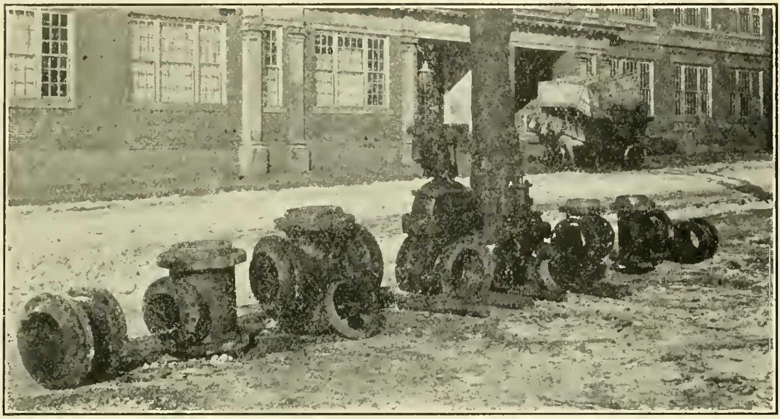
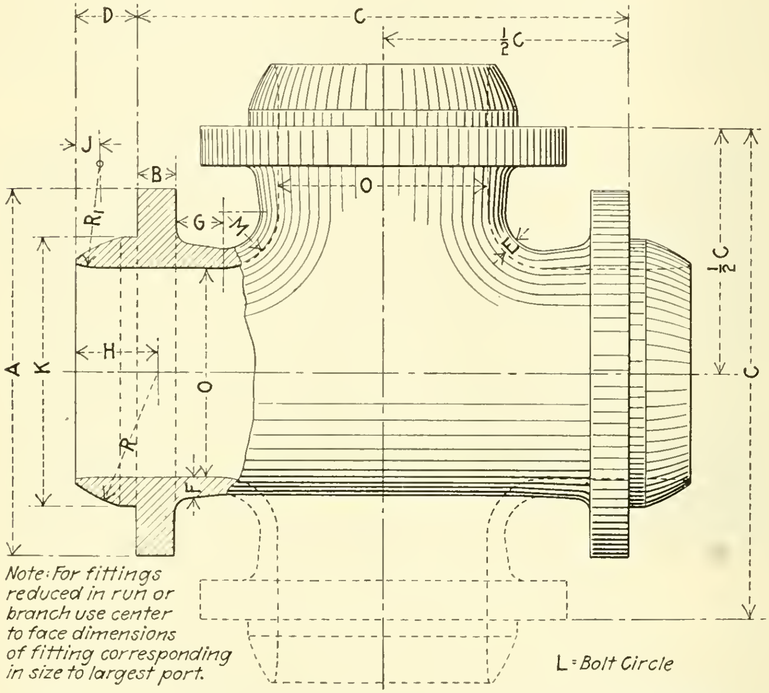


Fig. 10 Cast Steel Specials

34 *Flanges.*—The loose ring flanges were of medium open hearth steel, ultimate tensile strength 60,000 to 68,000 lb. All flanges were accurately machined and were drilled to template.

35 *Fittings.*—The use of steel pipe made it possible to reduce the number of fittings to a minimum. The hydrant branches were made by welding necks to the mains and laterals. A special neck weld was used, made up as follows: A hole was cut in the pipe, smaller than the size of the neck, and radial cuts were made forming four narrow lugs which were left projecting into the hole. The wider alternate

lugs were bent back to make an opening large enough to receive the neck piece. The smaller straight lugs formed a support for, and held the neck rigidly in place during the welding process. The whole joint was then flowed with metal by an oxy-acetylene blow-pipe, forming a joint as strong as the original pipes (Fig. 9).

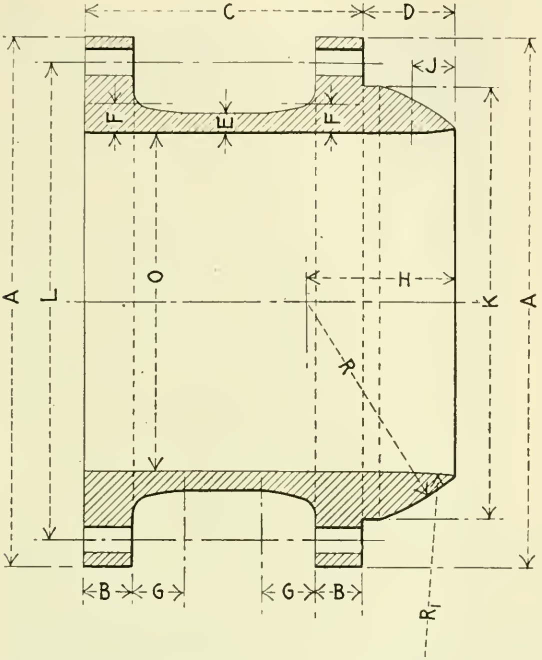

D
C
$\frac{1}{2}$C
J
B
R₁
G
M
O
E
$\frac{1}{2}$C
A
K
H
O
R
F
C
Note: For fittings reduced in run or branch use center to face dimensions of fitting corresponding in size to largest port.
L = Bolt Circle

SIZE	A	B	C	D	E	F	G	H	J	K	O	R	R₁	L	M	BOLTS		
																NO.	DIA.	HOLE DIA.
10"	$17\frac{1}{4}$"	$2\frac{1}{8}$"	$23\frac{1}{2}$"	3"	$\frac{13}{16}$"	$1\frac{1}{8}$"	$2\frac{1}{4}$"	4"	$1\frac{1}{8}$"	$12\frac{27}{32}$"	10"	$6\frac{21}{32}$"	$3\frac{5}{8}$"	$14\frac{3}{4}$"	$2\frac{5}{8}$"	12	$1\frac{1}{8}$"	$1\frac{1}{4}$"
16"	$23\frac{1}{2}$"	$2\frac{1}{2}$"	30"	$4\frac{3}{8}$"	$\frac{7}{8}$"	$1\frac{1}{4}$"	$2\frac{1}{2}$"	6"	$1\frac{1}{2}$"	$20\frac{13}{32}$"	$15\frac{1}{8}$"	$9\frac{29}{32}$"	$6\frac{1}{4}$"	21"	$2\frac{3}{4}$"	16	$1\frac{1}{8}$"	$1\frac{1}{4}$"
24"	33"	$2\frac{3}{4}$"	41"	$3\frac{7}{8}$"	$1\frac{1}{16}$"	$1\frac{1}{2}$"	3"	$8\frac{3}{8}$"	$2\frac{1}{4}$"	27"	23"	$14\frac{19}{32}$"	7"	30"	3"	24	$1\frac{1}{4}$"	$1\frac{3}{8}$"

FIG. 11 DETAIL OF TEES AND CROSSES

36 The only specials required were the tees and crosses at the intersections of the gridiron, and a valve connection piece used to give a straight face flange at the valves. By the use of the latter it was possible to use standard commercial valves, and the valves may be easily removed when necessary (Figs. 10, 11, 12). All fittings were made of low carbon open hearth cast steel.

37 *Valves.*—All valves are double-disc parallel seat gates. Bodies are low carbon open hearth steel of the same specifications as for fittings. Bonnets, discs, gearing brackets, glands and packing boxes are of semi-steel. Stems are of Tobin bronze, not less than 53,000 lb. tensile strength. Seats, wedge mechanism and glands are of bronze. The 16-in. and 18-in. valves are geared. All street valves are provided with a stem nut, and a forged steel key is placed in each valve box. An interlocking arrangement is provided so that the key can be removed from the nut only when the valve is wide open. This prevents the valves being left closed or opened only a few turns, except in an emergency or intentionally, as the valve box



SIZE	A	B	C	D	E	F	G	H	J	K	R	R₁	O	L	BOLTS		
															NO.	DIA.	HOLE DIA.
8"	14¾"	1⅞"	10½"	2 15/16"	¾"	1⅛"	2¼"	3¼"	1"	10 9/16"	5¼"	3½"	7¾"	12¼"	8	1⅛"	1¼"
10"	17¼"	2⅛"	11½"	3"	¾"	1⅛"	2¼"	4"	1⅛"	12 27/32"	6 21/32"	3⅝"	9⅞"	14¾"	12	1⅛"	1¼"
16"	23½"	2½"	13"	4⅜"	⅞"	1¼"	2½"	6"	1½"	20 13/32"	9 29/32"	6¼"	16"	21"	16	1⅛"	1¼"
24"	33"	2¾"	14½"	3⅞"	1 1/16"	1½"	3"	8⅜"	2¼"	27"	14 19/32"	7"	23"	30"	24	1¼"	1⅜"

Fig. 12 Detail of Valve Connecting Piece

cover cannot be replaced while the key is on the nut. The 24-in. valves are in the pumping station and are hydraulically operated. All valves were subjected to a shop test of 800 lb. when open, and 600 lb. when closed.

38 *Valve Boxes.*—The street valves are treated as pieces of mechanism, subject to derangement, and hence are placed in concrete boxes or manholes, 42 in. inside diameter, where they can be inspected and repaired without disturbing the street paving The floor was first laid of plain concrete, with suitable drainage connection; then the section enveloping the pipe or fitting was laid up with concrete blocks molded to the standard radius. The upper clear section was built of reinforced concrete rings, laid up without mortar, as they are provided with interlocking projections on the top and bottom faces, which make the rings self-centering. The upper portion is made of conical shaped rings, forming the roof, and supporting the cast-iron cover frame. The blocks and rings were made up in quantities in metal molds and seasoned before being used. They

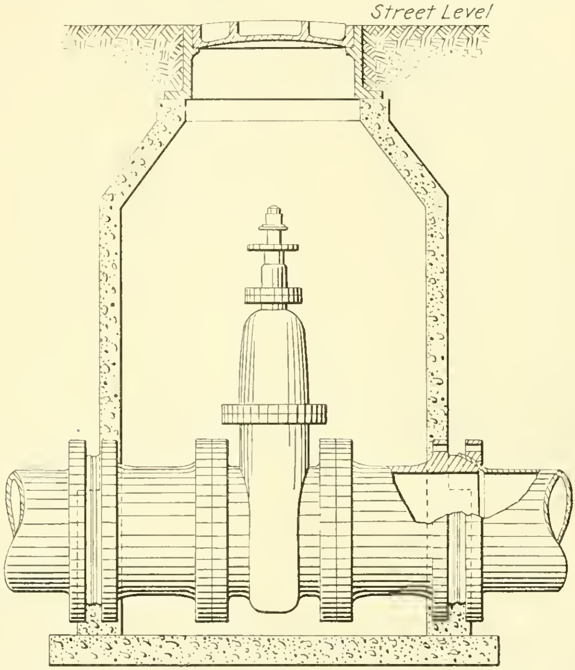


Fig. 13 Valve Box with Valve in Place

were quickly and easily assembled in the trench by unskilled labor. The holes were back-filled and the street repaved in a remarkably short time, an item of considerable importance in a business thoroughfare as there was no time required for setting of the concrete. (See Figs. 13 and 14).

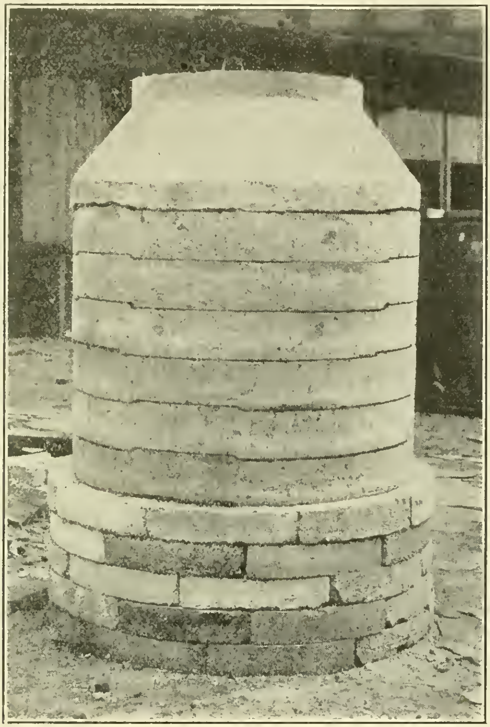


Fig. 14 Concrete Valve Box Made Up

LOW-PRESSURE WATER SUPPLY

39 Two separate 40-in. mains from two different river systems, run direct to and form the normal supply for the high-pressure pumping station. The normal pressure available with the high-pressure draft included is from 30 to 50 lb., but if by-passed from the middle or high-service mains, the pressure can be carried at 70 lb. A 30-in. cast-iron branch is taken to the station where it changes to a 30-in. rivetted steel pipe inside the building.

40 An auxiliary supply of brackish water from the harbor may

be secured through a reinforced concrete conduit 3 ft. sq. inside. The conduit is provided with a large screen chamber at the dock, and has fine and coarse screens sliding in inclined frames, and both in duplicate, so that one set of each can be in service while the other set is out for cleaning. The screen chamber is also provided with stop logs so that the chamber and conduit can be pumped dry for cleaning out sediment. At the station end the conduit terminates in a large suction chamber located beneath the basement floor and between the pump foundations. The dimensions of this chamber are 8 ft. wide, 7 ft. deep and 70 ft. long. The gravity suction pipes enter the suction chamber through cast-iron thimbles built into the floor of the basement, as the basement floor is 8 or 9 ft. below flood tide level.

41 A by-pass from the high-pressure discharge main is led into the suction chamber for flushing it, and also forms a convenient discharge for the pumps during tests.

INSTALLATION OF PIPE LINES

42 *Tunnels.*—A considerable amount of tunneling was done, especially at street intersections, where double track crossings of the street railway were frequently encountered. On several of the busiest streets it was found necessary to tunnel for many blocks at a stretch. In a large number of instances it was thought desirable to tunnel for the hydrant branches, as the hydrants being staggered on opposite sides of the street, it was necessary on every alternate hydrant to cross the street, thus crossing also the railway tracks, pipes, sewers, electric conduits, etc. A segregation of these tunnels into groups is as follows:

	Lineal Feet
Intersections	5122
Straight line	4623
Hydrant connections	2630
Total tunnels	12,375

43 *Leakage.*—For field tests during the installation of the pipes, the contractor furnished a portable testing set consisting of a 3-h.p. 4-cycle gas engine, driving through a Morse chain a triplex plunger pump of a capacity of 5 gal. per min. at a pressure of 1000 lb. per sq. in. Each street section between valves was tested as the work was installed, and made absolutely tight, at the specified pressure of 600 lb. The section to be tested was filled from the ordinary fire

hydrants, after which the test pump was connected through a 1-in. flexible steel hose. In the early stages of the construction, the workmen would frequently carry the pressure up to 800 lb. and sometimes to 1000 lb., to show interested spectators what the new joint would stand. Afterwards a relief valve set for about 610 lb. was placed on the pump, and the testing became almost automatic.

44 After the pipe lines had been completed, but before the system had been put into commission, a pressure of about 300 lb. was put on the pipe lines by the main pumps. There being no hydrants open, the water was being wasted through a by-pass to reduce the pressure. A suggestion was made to close the pipe system off from the pumps to determine how long the pressure would remain. The main 24-in. valves were accordingly closed, while the pressure was at 125 lb. After a lapse of 16 hours the gage registered 95 lb., indicating that the leakage was practically nothing.

45 A duplex pump of 1000 gal. capacity was installed to keep up the pressure and take care of the leakage on the system. Since the equipment has been put into regular service it has been necessary to keep the by-pass valves open continually on this pump in order to permit the plunger to move.

CHOICE OF MOTIVE POWER

46 *General Considerations.*—In the preliminary studies for the project, careful attention was given to the design of similar plants in other cities, notably New York and Philadelphia. In the former, as is well known, electric driven centrifugal pumps are used. In Philadelphia, gas engine driven, geared triplex plunger pumps were installed. In the following discussion it should be remembered that local conditions often exercise a controlling influence in the decision as to the best form of motive power for such a plant.

47 In Baltimore the fundamental principle governing the design of the entire project was considered to be reliability under the most adverse conditions liable to be encountered. When it is considered that the safety of hundreds of millions of dollars worth of property is dependent upon the accurate functioning of each element, it is evident that no considerations of economy, either in first cost or operating expense, should be allowed to enter, if simplicity and certainty of operation are thereby subordinated.

48 *Gas Engines.*—The gas engine is subject to certain limitations, which in the case of fire service, place it at a distinct disadvantage.

a The load factor of the service is extremely low, being less than 5 per cent per annum, so that the opportunity to profit by the high fuel economy is negligible.

b Inability to carry more than a small percentage of overload.

c In the hands of expert operators, a well designed modern gas engine is perhaps subject to no more accidents or delays than is a steam equipment, but certainly it is not subject to any *less* than steam. On the contrary, however, in the hands of operators of only average intelligence or experience, the number of apparently trivial causes which can result in serious delays or damage is surprisingly large in a gas engine plant. In the case of a municipal plant of this type it is useless to plan for ideal operating conditions, or to assume that only the highest grade operating force will be employed.

49 *Electric Motors.*—In spite of its many known advantages, a large electrical distributing system is essentially in unstable equilibrium, and subject to complete interruption from very slight causes, either natural or malicious. Dependence for prompt renewal of the service after a shutdown must be placed in duplicate lines and equipment in the stations. But even with these a considerable period must elapse before large electrical machines can be started up and brought into synchronism. A delay of this character during the first critical minutes of a bad fire would be fatal to the usefulness of an important fire fighting system. The fact that a vital feature of the fire fighting system would be under the control of employes of an outside corporation and not subject to the discipline of the fire department, with the possibility of a conflict of authority at a crucial moment, are all matters that must be considered.

50 Like the gas engine, the electric transmission, especially the underground system, requires for its commercially profitable conditions a high load factor, but for a different reason. To justify the large investment needed, requires a uniform load as near as possible to its capacity, in order that the fixed charges shall not be out of proportion to the earnings. Owing to the extremely low load factor of a fire station, its load is a very "undesirable" one to a commercial electrical supply corporation, unless a "demand" charge is made sufficient to justify holding in reserve a definite proportion of the entire equipment from the coal pile to the electric cables. Electrical plants require the installation of sufficient equipment all along the line to supply the maximum annual peaks. As a fire is no respector of anybody's peaks, it follows that a fire station load demands its

own separate power plant investment, whether the equipment is located in a commercial central station, or in an isolated plant for its own use.

51 A commercial plant is designed with a definite load factor in view, ranging usually from 30 to 50 per cent. For these conditions the most efficient equipment is justified, with all the refinements of modern fuel and labor saving auxiliaries in a large plant. If a load factor of only 5 per cent had been imposed, however, a very different type of equipment would have been selected, at a very much smaller investment.

52 The various links in the chain of an electrical supply equipment (not considering a long distance transmission) would be as follows:

a Coal handling apparatus
b Boilers and auxiliaries (stokers, stacks, economizers, heaters, etc.)
c Steam turbines and auxiliaries
d High-tension generators
e High-tension switching apparatus
f High-tension cables

and at the receiving end

g High-tension switches
h High-tension motors
i Centrifugal pumps

53 If a long distance transmission were included, there would be added step-up transformers, aerial lines, a substation with step-down transformers and switching apparatus. If low-tension motors were used, additional transformers would be required.

54 An isolated steam pumping station, designed for the purpose, eliminates at once five of the above links, namely, items *d*, *e*, *f*, *g* and *h*, and concentrates the entire operation in one building, under the direct control of the fire fighters themselves.

55 *Finances of Steam and Electrical Operation.*—Expressed in dollars and cents the argument becomes as follows:

Electric Pumps (New York Type)

Investment		
5 motor driven pumps (rated capacity 3000 gal. per min.), switchboard, etc.	$112,500	
Building and pump foundations	84,000	
		$196,500

Operation			
Maintaining pressure continually 8760 hr. less 100 hr. = 8660 hr. at 100 kw			866,000 kw-hr.
Fire service, 100 hr. per annum 3150 kw. demand			315,000 kw-hr.
			1,181,000 kw-hr.
Service charge, maximum demand =		3150 kw.	
Central station investment, 3150 kw. at $75		$236,000	
Underground cable (Baltimore conditions)		40,000	
Cash requirements		276,000	
Underwriting at 90		31,000	
Total investment			$307,000
Fixed charges on $307,000			
Interest	at 5 per cent		
Depreciation	at 5 per cent		
Profit	at 5 per cent		
Total	15 per cent	$46,000	
Underground conduits, duct rental (Baltimore conditions)		1,300	
Total service charge			$47,300
Operating expenses			
Service charge		$43,700	
Meter charge, 1,181,000 kw-hr. at 1 cent		11,810	
Salaries, station operating force		10,650	
Supplies, lubrication and repairs		1,000	
			$67,160
Fixed charges on $196,500			
Interest at 4 per cent		$7,860	
Depreciation at 5 per cent		9,825	
			17,685
Total annual expense, electrical plant			$84,845

STEAM PUMPS

Investment		
Four 4000-gal. pumps and auxiliaries	$86,000	
Boilers and auxiliaries	70,000	
Piping, steam and auxiliary water	30,000	
	$186,000	
Building and machinery foundations	125,000	
		$311,000

Operation		
Coal consumption		
Banking fires, 8760 hr. — 100 hr. =8660 hr. = 360 days at 6 tons per day	2160 tons	
Fire service, 100 hr. per annum at 5 tons coal per hour	500 tons	
Total	2660 tons	
Operating expenses		
Coal, 2660 tons at $3.30	$8,778	
Salaries, station operating force	13,350	
Supplies, lubrication and repairs	2,000	
		$24,128
Fixed charges on $311,000		
Interest at 4 per cent	$12,440	
Depreciation at 5 per cent	15,550	
		27,990
		$52,118
SUMMARY		
Total annual expense, electrical plant	$84,845	
Total annual expense, steam plant	52,118	
Total annual saving		$32,727

This saving capitalized at 9 per cent represents an investment by the city of $363,630, considerably more than the first cost of the steam plant in the above comparison.

STEAM PUMPING STATION

56 *Pumps.*—The Baltimore plant is designed for four main units of 4000 gal. per min. rated capacity, at a piston speed of 300 ft. per min. and making 50 r.p.m. Three main engines have been installed and are in operation at present; the fourth unit will be added in the near future (Fig. 15).

57 In line with the policy of designing all parts of the system with a first requisite of simplicity and reliability, the main units each consist of a horizontal, twin, simple, non-condensing, crank and flywheel, plunger pumping engine. The water ends are attached directly to the engine frames, at opposite ends from the steam cylinders, the crank shaft being in the center (Fig. 16).

58 The steam cylinders are fitted with standard Corliss valve gears, having double eccentric long range cut-offs. The cut-offs of

both cylinders are under the direct control of the speed and pressure regulators, and are also provided with hand control.

59 Each engine was liberally designed for a continuous working pressure of 300 lb. per sq. in. on the water ends, with a test pressure of 600 lb. static. Injection parts were designed for a variation of pressure from 70 lb. direct to a suction lift of 15 ft. of salt water. All steam parts were designed for maximum working pressure of 200 lb., but the normal working pressure is only 125 lb.

60 Each engine is fitted with speed and pressure governors. The speed governor is driven by a noiseless chain belt, and acts directly on the cut-off valves of both cylinders. The pressure governors are identical in principle with the regulating valves used on the hydrants, and were also furnished by the Ross Valve Mfg. Co.

61 The net effective valve area between the openings of the valve seats on each suction and discharge deck is 308 sq. in. or 220 per cent of the cross sectional area of the plungers. The valves are $3\frac{1}{2}$ in. in diameter and are composed of rubber with brass backing plates; the seats are of bronze, screwed into the valve decks on a taper and faced off after being placed in the decks.

62 *Auxiliaries.*—To take care of the leakage in the pipe system and maintain a pressure of 150 lb., as well as to provide for the first draft from the hydrants before the main pumps are in action, a 1000-gal. per min. pump was installed. This is a horizontal, duplex, direct-acting, compound, non-condensing, center-packed plunger pump, giving its rated capacity at a piston speed of 100 ft. per min. While the pump was designed for a normal working pressure of 150 lb. on the water end, and for 125 lb. on the steam end, all pressure parts were designed to withstand a continuous pressure of 300 lb. on the water end and 200 lb. on the steam end, so that the pump could be left in service under the maximum pressures of the main pumps without injury. Owing to the leakage on the system being so small, the pump is inconveniently large for the purpose intended, and it has been necessary to keep the delivery by-passed continuously in order to keep the plunger in motion.

63 In order to maintain the air in the delivery air chambers, there are provided two steam driven, crank and flywheel, two-stage air compressors, each having a capacity of 50 cu. ft. of free air per min. against a pressure of 450 lb. There is also provided a wrought steel storage tank 30 in. in diameter by 5 ft. high. There are two large air chambers on the 24-in. discharge mains, in addition to those on the pumps. The former are made of lap-welded rolled steel pipe,

½ in. thick, 30 in. in diameter and 20 ft. high. The ends are bumped, riveted and welded to the pipe. Two sets of glass gages are attached through bosses welded on the sides.

64 For priming purposes, when lifting from the harbor, there is provided one vertical, steam driven, crank and flywheel single-stage, dry vacuum pump, 6 in. steam, 10 in. air, and 6 in. stroke. This pump is connected to the harbor suctions through a large separator tank at the top of a 40 ft. riser, to prevent water being drawn over into the air cylinder.

65 The plant is provided with a four-motor, electric traveling crane, main hoist 20 tons capacity, auxiliary hoist 5 tons. For lighting the station and for the operation of the electrically driven auxiliaries, there are provided two non-condensing steam turbo-generators.

66 *Tests and Duty Trials.*—The specifications for the pumps provided for an endurance and capacity test of 24 consecutive hours.

67 A normal load duty trial was also specified, covering a period of 12 hours; steam pressure at the throttle 125 lb. The steam consumption was to be based on the feedwater supplied to a separate boiler blanked off from all other sources of supply. The measured consumption was to include all jacket steam, but not that required for boiler feed pumps and other auxiliaries, nor separator condensation and drips from the steam piping on the boiler side of throttle.

68 In order to avoid the insertion of a water meter in either the main suction or discharge lines, a venturi meter is by-passed around a gate valve in the 30-in. city water supply. As the pump discharge can be accurately measured from the record of the pump strokes for a given period, when the slip is known, in this case the venturi meter is only used to calibrate the slip of a single pump, and therefore has a capacity only equal to one pump.

69 The duty specified is 70,000,000 ft-lb. per 1000 lb. of dry steam, under normal operating conditions of 3000 gal. per min. discharge, against a head of 250 lb., with 30 lb. pressure on the suction, and 125 lb. of steam at the throttle.

70 *Boilers.*—The plant is designed for four boilers, each set singly, and each provided with a separate stack carried on structural steel supports directly over the setting. At this time only three boilers have been installed, the fourth will be added in the near future (Fig. 17.)

71 The boilers are of the horizontal, inclined, straight tube type, with forged steel water legs reinforced with hollow staybolts. Each

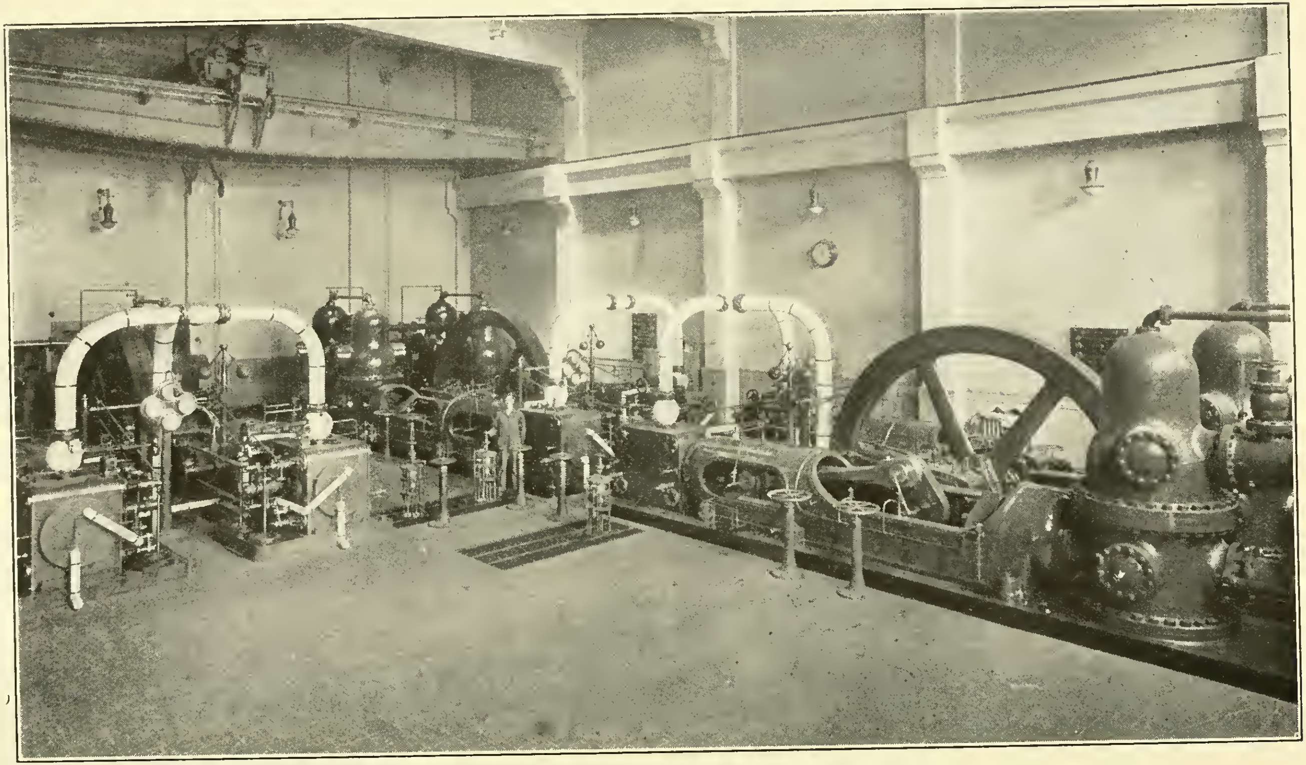


FIG. 15 INTERIOR OF STATION

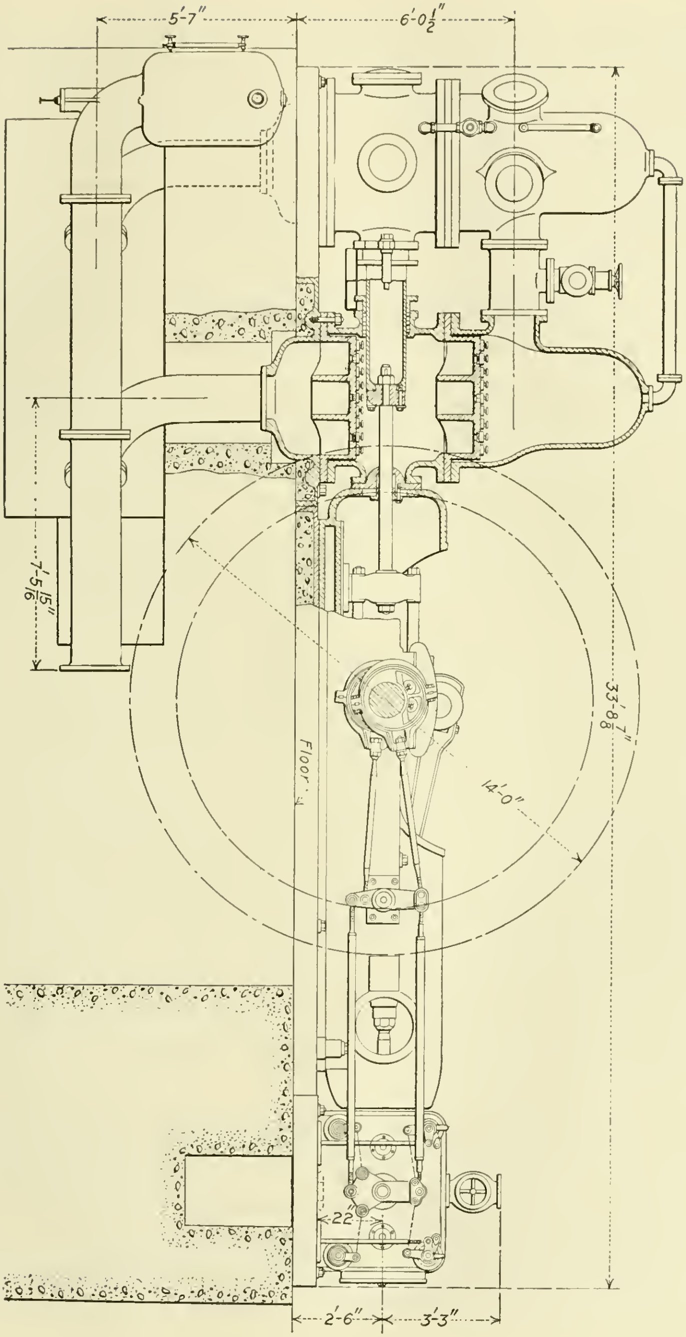


FIG. 16 ELEVATION OF PUMP

boiler contains 6800 sq. ft. of heating surface, and three 36-in. drums. All pressure parts are designed for 200 lb. working pressure. Each boiler is capable of a continuous evaporation of 45,000 lb. of water from and at 212 deg. fahr. into commercially dry steam, when burning semi-bituminous coal of approximately 14,500 B.t.u., with forced draft not exceeding 3 in. of water in the ashpit, or the equivalent of 1 boiler h.p. from 3.77 sq. ft. of heating surface.

72 As the actual time during which the boilers will be in active service will probably average only about 100 hours per annum, the plant was designed for carrying banked fires for a large proportion of the time, with the least possible loss from radiation. The top, sides and rear of each boiler are enclosed in an air-tight steel plate casing. The hotter portions of the side walls, amounting to about 20 per cent of the area of these walls, are covered with 2 in. of magnesia blocks inside the casing. The casing plates are supported on a framework of steel angles, attached to the structural steel members supporting the boilers and stacks. These angles act also as buckstaves for the settings. Access and dusting doors are provided where necessary, which are hinged at the top and close tightly on inclined faces.

73 The boilers are set in the reverse direction from the usual method, that is, with the low end of the tubes over the furnace. The front portion of the furnace is covered with a flat fire brick arch, made of split tiles encircling and supported by the lower row of tubes. When under fire, there is presented to the furnace gases an incandescent firebrick surface, instead of the customary cool iron surface of the tubes. The first pass of the gases between the tubes is at the extreme rear of the boiler, thus providing a furnace area equal to the entire floor space occupied by the boiler inside the setting, and making it possible to force the boiler to 90 per cent over the customary rating without imperfect combustion. A special grade of firebrick was used for the furnace lining, which under a change of temperature of 3100 deg. fahr. shows an expansion or contraction of less than 0.01 in. per ft.

74 *Forced Firing.*—The conditions of fire service require that the boilers shall be capable of changing from banked fires to the maximum capacity in the shortest possible time. The intervals specified were as follows: one-half rated capacity in 5 minutes; full rated capacity in 12 minutes; overload of 75 per cent in 20 minutes.

75 *Choice of Fuel.*—The above conditions made imperative the use of a gaseous fuel, or fuel oil, or forced draft with coal. The

possibility of the use of a combination of two of these was also considered. With gas at 90 cents per 1000 ft., this material was abandoned. The use of crude oil was given careful study. Due to the fact that economy of operating expense was not the primary consideration, the problem was somewhat simplified.

76 As the plant is located in a wholesale district where high values of stock are common, it would have been necessary to have stored the main supply of oil underground. Ample space for this purpose existed in the wide water front street about 200 ft. from the station. On the other hand, experience has demonstrated that oil should be fed to the burners only by gravity from an overhead storage of suitable capacity. Experience has also shown that in spite of all precautions, an oil storage tank will in all probability, sooner or later, take fire. It was of course, possible to design a fireproof barrier which would prevent the fire doing damage to adjoining property. It was believed, however, that in a plant designed for fighting conflagrations, the possibility of an oil fire, with its huge volumes of dense black smoke, would not tend to popularize the system, even if the fire proved to be entirely harmless. In spite of its recognized advantages in ease of handling and quick firing, the use of fuel oil was therefore definitely abandoned, and coal was adopted. The introduction of natural gas from the West Virginia fields has been under consideration for some years, and if this should be accomplished, it would make an admirable fuel for the purpose, either alone or as supplementary to the coal furnaces.

77 *Automatic Mechanical Stokers.*—The use of coal made necessary also the use of forced draft. In addition, it was desirable that during the periods of banked fires, there should be maintained a full bed of ignited coal, requiring only the air blast to force the fire to the highest rate of combustion. The underfeed type of stoker seemed to meet these conditions very satisfactorily. A large body of coal, approximately 1000 lb., can be carried in each furnace, a part of this coal incandescent, a part coked and a part in the process of coking. This represents about 14,500,000 B.t.u. in storage ready for use on a few minutes' notice. As a further heat storage, the steam pressure, which is ordinarily carried at about 150 lb., can be raised to 200 lb., immediately upon the receipt of an alarm. As the normal operating pressure is only from 125 to 150 lb. at the pump throttles, by the time the hose companies can reach the hydrants and attach the hose, and put a sufficient draft on the pumps to pull the steam down to normal, the furnace fires will be ready to respond to any demand.

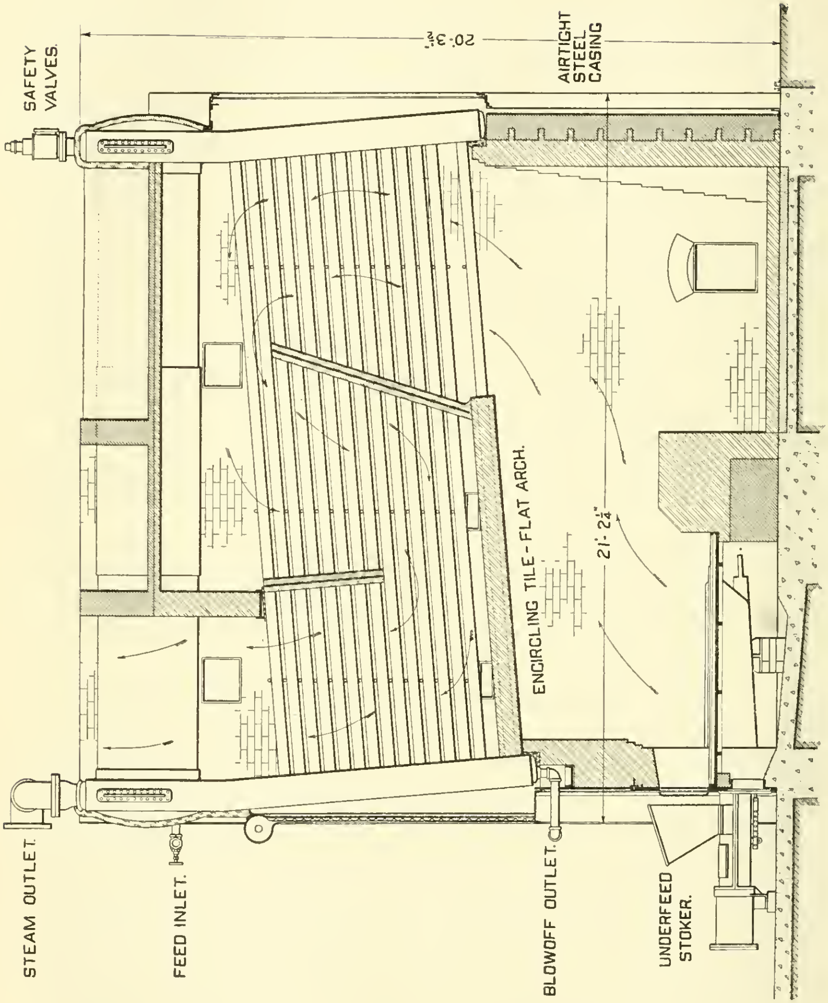


Fig. 17 Section of Boiler

78 Each boiler is equipped with four underfeed stokers, and each stoker unit is capable of burning efficiently, without smoke, 1000 lb. of coal per hour. For the four boilers a duplicate blower equipment is installed, each consisting of a full housed steel plate fan of sufficient capacity to operate the four boilers at 75 per cent overload. Each blower is driven by a direct coupled vertical steam engine. Each blower is connected to the main air pipe line, and by means of dampers either blower can be used to serve any or all the boilers.

79 To regulate the supply of both fuel and air in the proportion required for complete combustion under all rates of firing, the stokers are provided with automatic regulators actuated by the boiler pressure. Provision is also made for hand regulation, so that it is possible to anticipate sudden demands for steam upon receipt of an alarm, and also for decreasing the supply of both fuel and air when the demand for forced firing has passed.

80 *Stacks.*—Each boiler is provided with a separate steel stack located directly over the boiler which it serves. Each stack is 72 in. diameter by 125 ft. above the boiler room floor, and is carried by structural steel framing from the boiler foundations. The stacks are unlined.

81 *Coal Handling and Storage.*—Semi-bituminous run of mine coal is used almost entirely for steaming purposes in the vicinity of Baltimore. In this instance the coal is delivered in carts, the total annual consumption being too small to justify mechanical handling under existing conditions. The coal is dumped on a grating over an opening in the sidewalk, the mesh being 4 in. sq. Large lumps are broken up with a maul, as with the type of stoker in use there is no necessity for the coal to be crushed to smaller sizes. Below the grating there is a dumping hopper which receives the coal and delivers it to the lower run of a bucket elevator. The elevator is a double strand link belt with V-shaped buckets, 16 in. by 15 in., dumping by gravity. The outfit has a capacity of 25 tons per hour with uniform feed.

82 The coal is delivered into reinforced concrete bunkers with inclined bottoms, located directly over the fireroom. The bunkers have a capacity of 150 tons without trimming, or sufficient to operate the entire plant at its maximum capacity for 30 hours. Coal can also be delivered from carts directly on to the boiler room floor, so that the operation of the plant is not dependent upon the coal handling equipment nor the storage supply.

83 *Boiler Feedwater.*—Boiler feedwater is normally supplied

from the city mains under 30 to 50 lb. pressure, sufficient to deliver to the open heaters in the gallery of the engine room, without pumping. In the event of an interruption to the city supply, the feed-water can be taken from a reserve supply stored in steel tanks in the basement under the boilers. For lifting from the storage tanks and delivering to the heaters a duplicate set of low-service duplex steam pumps is provided.

84 To avoid the loss of efficiency in the boilers due to scale, and the necessity for taking the boilers out of service for considerable periods while removing scale, a double unit hot process purifier and heater of the Cochrane type was installed, each half of ample capacity to handle the consumption of the entire plant.

85 The heaters are located in a gallery in the engine room, directly over the boiler feed pumps, thereby providing a gravity head of 25 ft. for the hot water to the pump suction. There are three duplex, outside end packed boiler feed pumps, brass fitted and with pot valves, designed for 300 lb. pressure.

86 In addition to the above, each boiler is provided with a Metropolitan Model O No. 17½ injector, capable of supplying the maximum evaporation of the boiler when lifting from the storage tanks in the basement.

87 Foster excess governors are provided on the feed pumps, and Williams regulators on the boilers.

88 *Piping.*—A 12-in. steam header forms a closed ring around the plant, with long radius expansion bends at all changes in direction (Figs. 18, 19, 20). A sufficient number of gate valves are placed in the header to sectionalize it, so that any portion may be cut out without disabling more than one boiler or one pump. Pipe is full weight, lap welded, soft open hearth steel. To provide an independent header for the station auxiliaries, a 6-in. cross connection is made across the center of the main header, which is capable of being fed from either side of the main header, in case of accident to the other. No fittings whatever are used in the main line, all branches being taken from interlocked welded necks. Boiler branches are provided with non-return valves at the boiler nozzles and gates at the header end. Van Stone flanges are provided for connections to the valves and receivers, which are located so as to avoid as far as possible the necessity for any additional joints in the line. Wrought steel receiver type separators are installed at the low points on each side of the header.

89 The exhaust system is extremely simple, a multi-port back

pressure valve on the 18-in. riser serves to turn all the exhaust into the heaters at light loads, and provides a direct path to the atmosphere when the steam is in excess of the heater requirements.

90 *Building.*—The site of the pumping station is a lot 69 ft. front by 137 ft. deep, running back to a 16 ft. alley. The property immediately adjoining on the two sides is occupied by warehouses carrying more or less inflammable stocks. On the opposite side of the alley the same conditions exist. All foundations for the pumping station and machinery were designed to rest on caissons carried to the gravel, so that it was necessary to underpin the walls of both the adjoining buildings.

91 All structural portions of the building, including columns, girders, beams, floor and roof slabs, and all walls except the front, are of reinforced concrete. The adjoining buildings on the sides are from 10 to 20 ft. higher than the station roof, so the roof girders, beams and slabs were designed to withstand the shock of falling walls in case of fire. The side walls are not less than 8 in. thick in any part, and have no openings whatever. The rear wall is the same, except that there is one door at the level of the boiler room floor.

92 For access to the men's quarters an automatic push-button electric elevator is installed, in addition to the stairway. Standard brass sliding poles are also provided for quick response to an alarm. The quarters are located over the front of the engine room, and include a dormitory, dressing room, bath, toilet and reading rooms. In addition, a private bedroom, bath, parlor and office are provided for the chief engineer.

93 In addition to the fireproof construction of the building, further fire fighting equipment for the protection of the station consists of a water curtain for the exposed front and rear, and two 8-in. standpipes, to be fitted with monitor nozzles. A dangerous fire in the immediate vicinity of the station could thus be effectively fought from the roof as well as from the ground.

94 *Signaling System.*—In addition to the regular fire alarm circuit, a separate telephone circuit runs to the pumping station from fire alarm headquarters, fire department headquarters, and the chief's night quarters. This circuit connects to contacts for portable telephones in each fire-alarm box in the high-pressure district. In addition to the regular Morse key and sounder there are contacts for a telephone connection in each box, over the fire alarm circuit. Finally there is available the regular public telephone service.

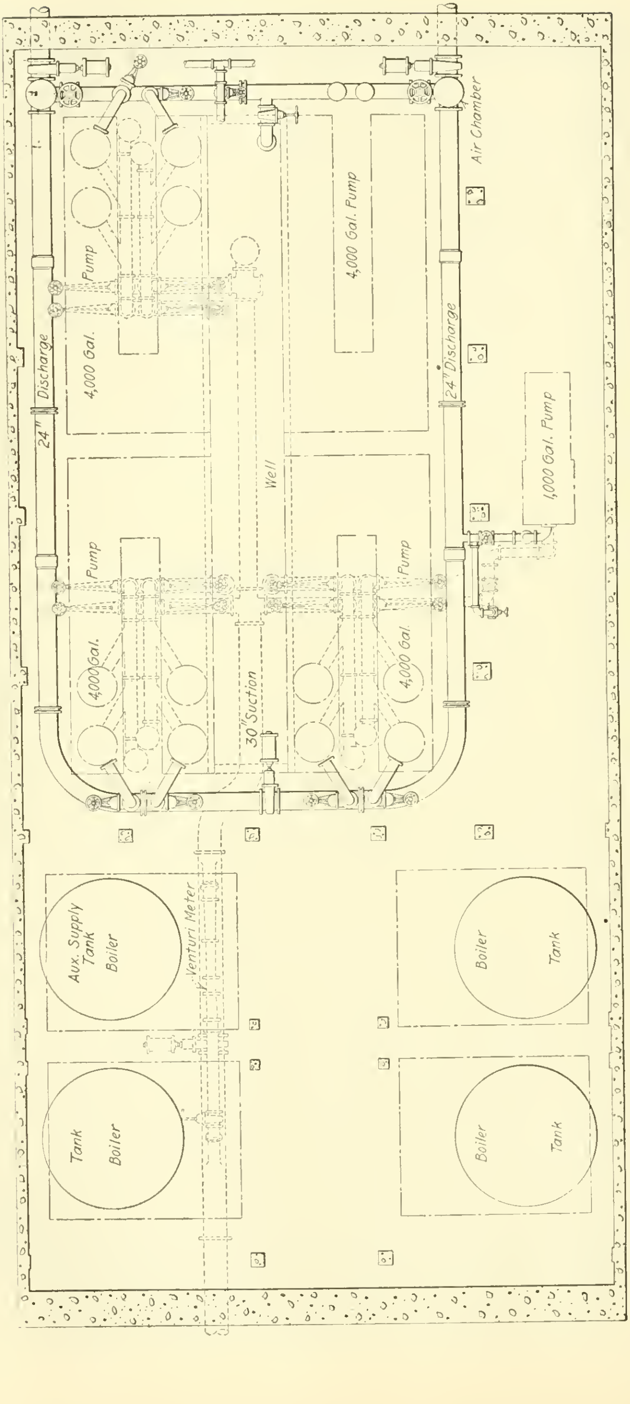


Fig. 18 Plan of Station, showing Water Piping

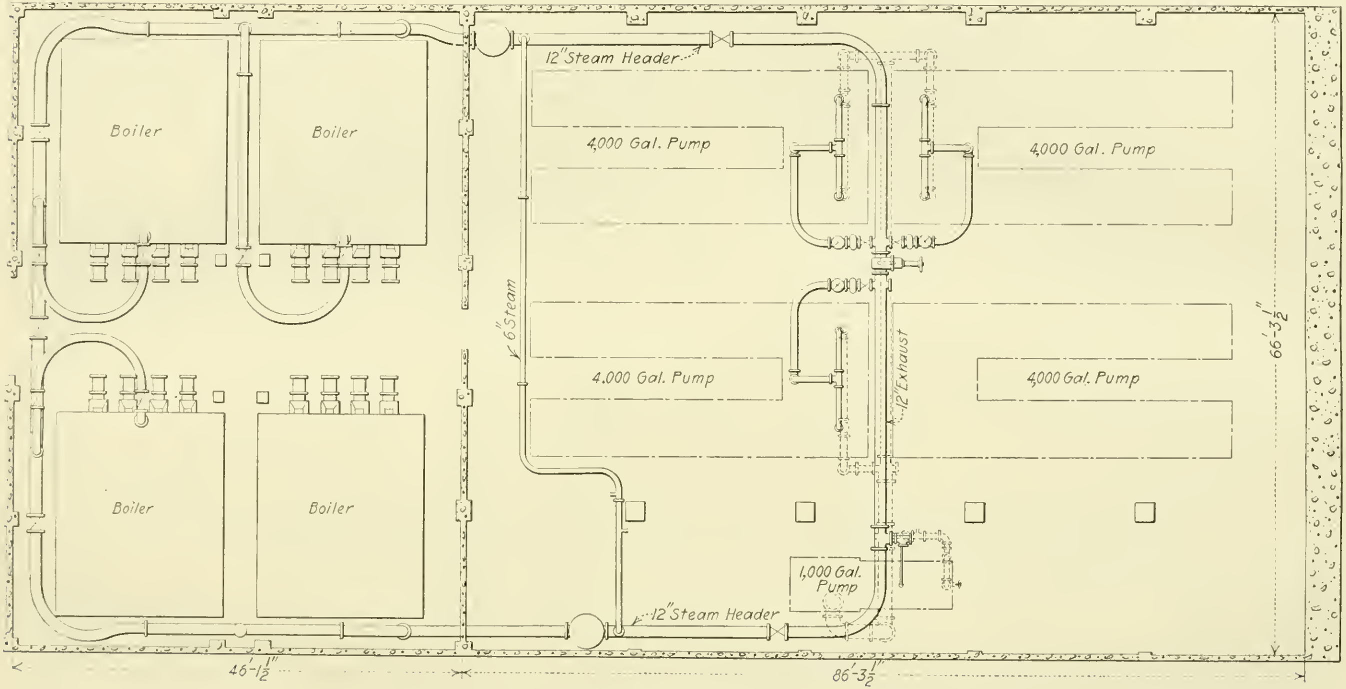


Fig. 19 Plan of Station, showing Steam Piping

CONSTRUCTION COSTS

Portable Equipment			
2 automobile hose wagons at $5000		$10,000	
8000 ft. 3 in. hose at $1		8,000	
30 portable heads and regulators at $385		11,550	
Total		$29,550	
Pipe System			
Material delivered Baltimore			
Hydrants, 226 at $100	$22,600		
8 in. pipe, 7137 ft. at $2.35	16,700		
10 in. pipe, 28,229 ft. at $3.10	87,700		
16 in. pipe, 17,052 ft. at $5.25	89,600		
24 in. pipe, 1275 ft. at $10	12,750		
8 in. gate valves, 6 at $100	600		
10 in. gate valves, 193 at $130	25,000		
16 in. gate valves, 90 at $210	18,900		
18 in. gate valves, 2 at $300	600		
24 in. gate valves, 3 at $1,000	3,000		
Air and relief valves	200		
Low pressure gates, 2–30 in.	500		
Suction pipe, 400 ft. cast iron, 30 in., at $4	1,600		
Steel air chambers, 2–30 in., at $500	1,000		
Venturi meter	500		
Cast steel specials	17,500		
		$298,750	
Installation			
Laying pipe, including placing valves, fittings, hydrants, etc.			
8 in. pipe, 7,137 ft. at $0.70	$4,996		
10 in. pipe, 28,229 ft. at 0.75	21,200		
16 in. pipe, 17,052 ft. at 1.15	19,600		
24 in. pipe, 1,275 ft. at 1.75	2,230		
Pump connections in station	6,000		
Laying 30 in. c. i. suction	3,400		
Tapping 40 in. main	1,500		
Concrete valve boxes, 293 at $30	8,790		
Excavation, back filling and rubble paving			
41,318 ft. open trench, at $3.84	158,600		
12,375 ft. tunnel, at $4.08	50,400		
Improved paving, 6650 sq. yd., at $1.50	10,000		
Superintendence, use of tools, etc.	50,000		
		$336,716	
			$635,466
Pumping Station			
Site and preliminary work		$37,730	
Building, including machinery foundations, and men's quar-			

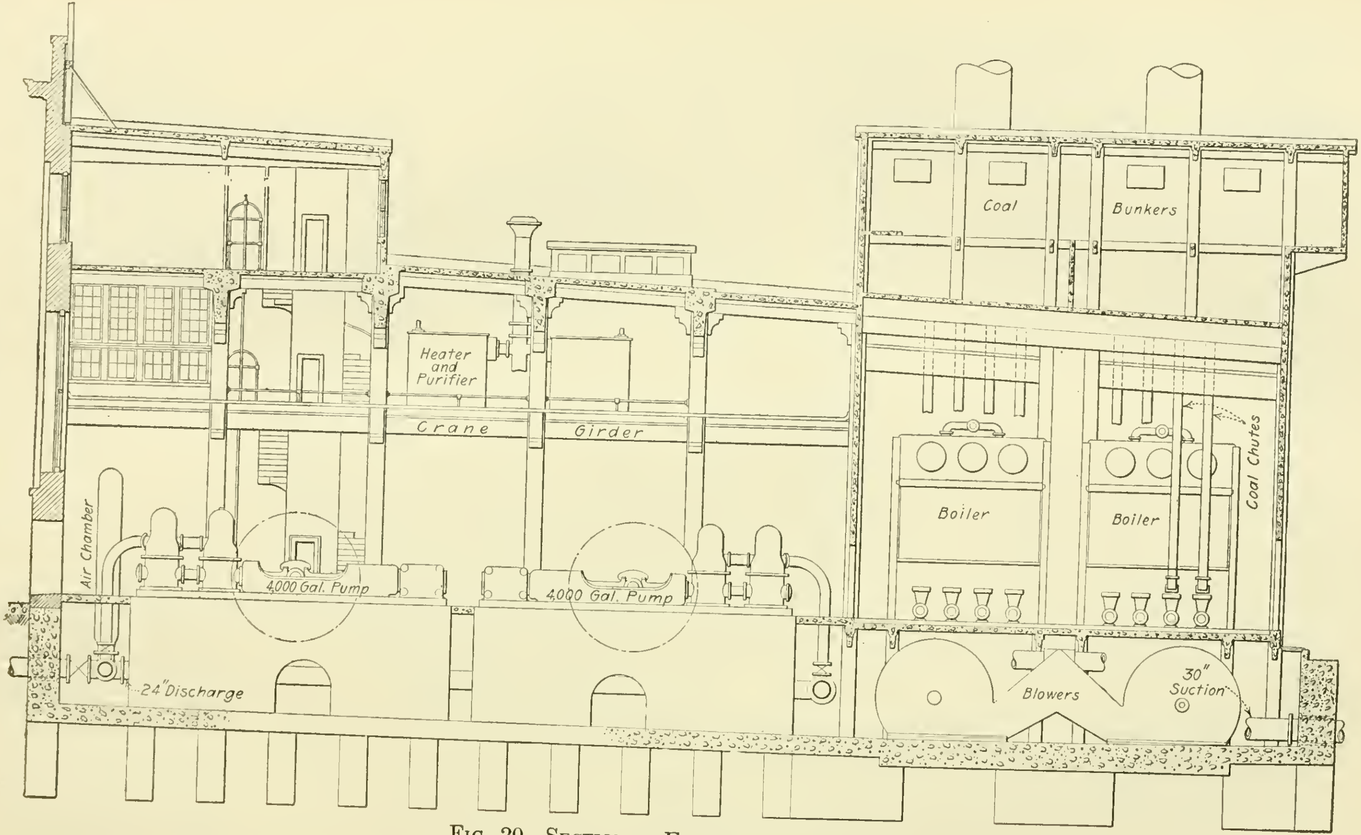


FIG. 20 SECTIONAL ELEVATION OF STATION

ters		124,800	
Harbor intake and screen chamber		10,000	
Equipment			
Four 4000 gal. pumps	$82,000		
One 1000 gal. pump	3,500		
Auxiliary pumps	4,250		
Feedwater heaters and purifiers	4,750		
4 boilers and settings, 27,200 sq. ft. heating surface	33,000		
16 underfeed stokers, blowers, air piping, etc.	18,000		
4 steel stacks and supports	8,000		
Coal handling apparatus	7,000		
Turbo-generators and switchboard	4,500		
Electric crane	4,000		
Steam and auxiliary water piping	30,000		
		$199,000	
			371,530
Miscellaneous			
Signal system, cables, etc.	$1,500		
Furnishings for men's quarters	500		
Incidentals	5,000		
			7,000
Engineering			50,000
Total cost of construction			$1,093,546

95 *Operating Department.*—The Board of Fire Commissioners is the executive head of the operating department, acting through the department chief. The operation and maintenance of the pumping station and the maintenance of the pipe lines, hydrants and portable heads are directly under the supervision of the department superintendent of machinery, Thomas H. Meushaw. The maintenance work for the pipe line is in charge of a general foreman, John Rudolph, who was chief inspector for the city during the early part of the installation, and general foreman for the contractor during the latter portion of the work.

96 The operating force at the pumping station is in charge of a resident engineer and five assistant engineers, with four stokers and two general assistants, all organized as a fire company. Two additional stokers have been recommended by the superintendent of machinery, and will probably be added in the near future, making a total station operating force of fourteen men. Of these an engineer and stoker are on active duty at all times, with a four-hour watch.

Immediately upon the receipt of an alarm all hands report on the operating floor. As a pressure of 150 lb. is maintained during the standby period, orders have been issued that in the event of the pumps automatically speeding up without an alarm, the plant shall be shut down immediately. This course is taken to avoid water damage, should a break occur. Up to this time no occasion has arisen to require the execution of this order, however.

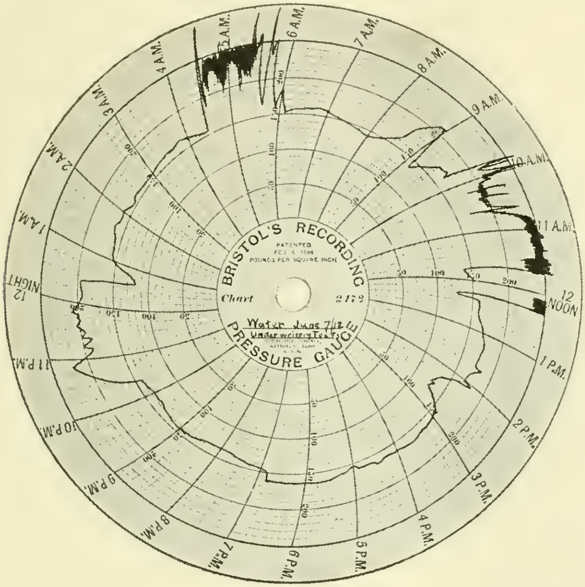


FIG. 21 CURVE OF WATER PRESSURE DURING UNDERWRITERS' TESTS

TESTS

97 *Opening Demonstration.*—The system was formally placed in operation on May 20, 1912, with a public demonstration on the Court House Plaza. At first twenty-four $1\frac{3}{4}$-in. streams were used from single hose lines held by tripods. Later seven $2\frac{1}{2}$-in. streams were thrown, from monitor nozzles on the wagons. About 13,000 gal. per min. were delivered.

98 *Underwriters Tests.*—A readiness test was made June 7, readings being taken by a stop-watch.

4.30.00 a.m. Fire alarm box pulled; one engineer and one stoker on duty at station.

4.31.00 a.m. Chief engineer with four additional engineers and three additional stokers had responded from sleeping quarters.

4.31.15 a.m. Two large pumps started up, pressure increased from 150 to 190 lb.

4.33.00 a.m. Pressure 280 lb. Hose company turned water on to two 3-in. hose lines siamesed into one 2½-in. monitor nozzle.

4.34.00 a.m. Discharge was 1050 gal. per min.

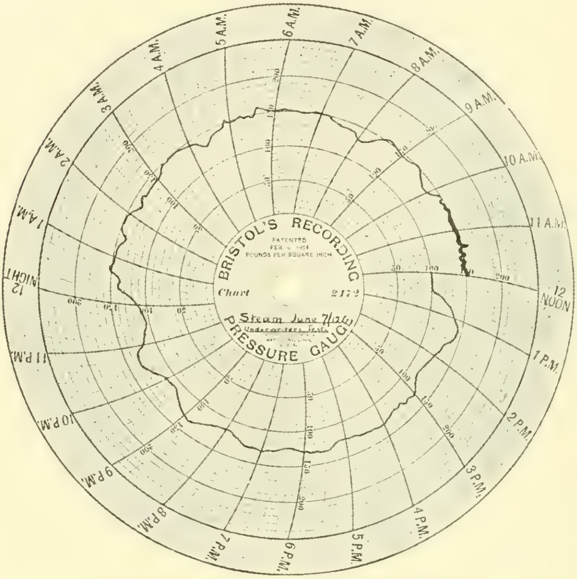


Fig. 22 Curve of Steam Pressure during Underwriters' Tests

4.37.40 a.m. Two additional 2½-in. nozzles in service, total discharge 4000 gal. per min.

99 A second company was then ordered into service at another point, with three 2½-in. nozzles, bringing the total discharge up to 7100 gal. per min. See water and steam charts from Bristol gage at station (Figs. 21 and 22).

100 A general performance test was made June 7, from 9.45 to 10.15 a.m. (see Bristol charts). Pumps were started and stopped, and hydrants were opened and closed as rapidly as possible to test the ability of the pumps and governors to take care of abnormal operating conditions.

101 Individual pump tests were made the same date, from 10.15 to 10.45 a.m., with the following results:

Steam at throttle, lb.	146
Water pressure, discharge, lb.	199
Water pressure, injection, lb.	41
Water pressure, net, lb.	158
Revolutions per minute	55
Discharge, gal. per min.	4592

102 A general capacity test was made 10.45 to 11.40 a.m., with the following results (three pumps in service):

Steam at throttle (average), lb.	145
Water, discharge, lb.	240
Water, injection	?
Water, net	?
Discharge, gal. per min.	12,770

103 During the latter test six 2½-in. nozzles and six 2-in. nozzles were in use, discharging into the harbor (see Fig. 23).

RESULTS OF OPERATION

104 The department chief is enthusiastic over the efficiency of the entire system as a modern fire fighting equipment. He makes the statement that during the two months which it has been in operation, three bad incipient fires have been literally "drowned out" by the system. The probable losses from these fires, under former conditions, would more than have equalled the entire cost of the high-pressure service. By the time the department arrived on the scene at one fire, the smoke was so dense that from the middle of the street it was impossible to locate any window or door openings in the building. Three 2½-in. monitor streams were blindly turned on the building. The water reached the fire, but not through windows or doors. When the smoke had cleared away, three holes were discovered in the 18-in. brick walls, bored straight through the masonry by the high-pressure streams.

105 The engineers of the National Board of Fire Underwriters, after a thorough test and a special search for weak points, reported as follows:

> The distributing system has been installed for two years and shows no signs of deterioration. The slight leakage, absence of electrolytic action and total freedom from breaks or other troubles appear to justify the departure from the usual design of such systems. . . . The valve and hydrant distribution is excellent, and the pipe sizes and gridironing are sufficient to enable a good concentration of flow without serious loss of pressure. . . . The separate hydrant head permits the use of regulator valves permanently attached, giving excellent control of the pressure on hose lines. The hydrant head under test showed sufficiently low friction loss. . . . The operation of the pumping plant is prompt and reliable.

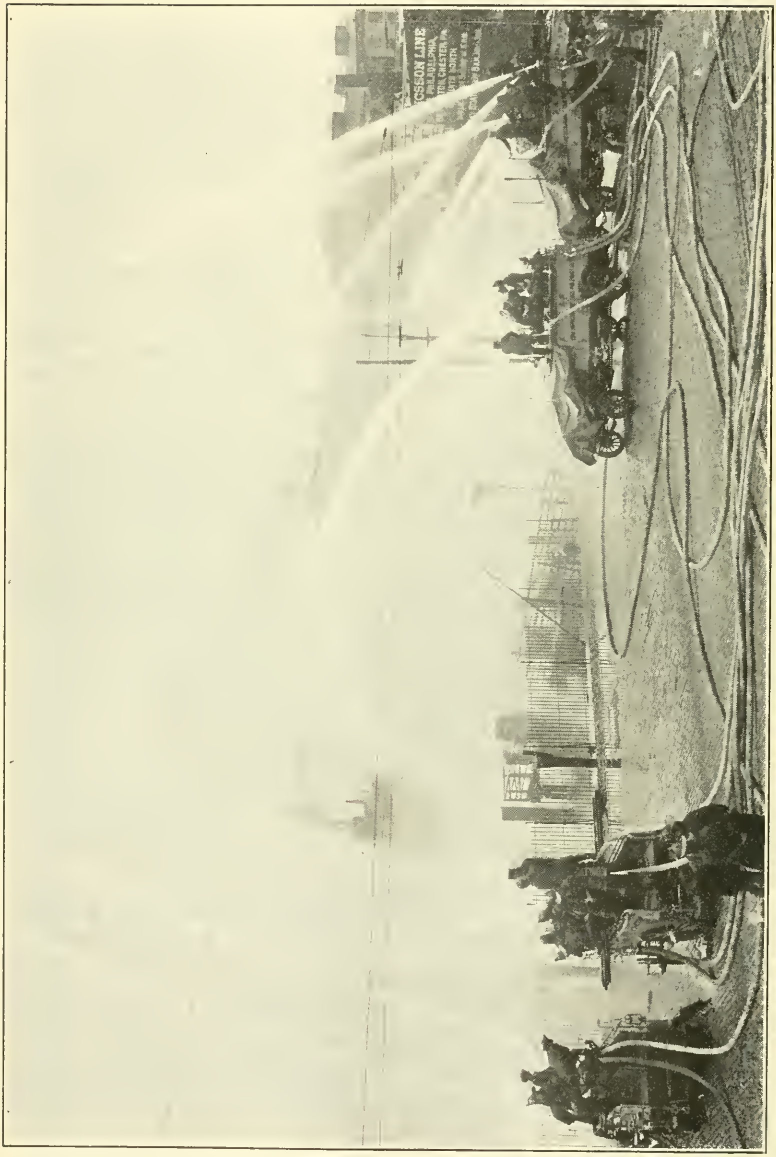


Fig. 23 View of Streams during Underwriters' Tests

106 As a result of the installation of the high-pressure system, the underwriters have announced a rebate of 5 cents in the insurance rate on all property in the district covered. While no exact summary has been made of the aggregate saving which will result from this reduction, it is roughly estimated that the amount will be approximately $40,000 per annum, which will be increased almost in direct proportion with the extension of the mains.

ORGANIZATION

Construction.—The executive head of the project is the Board of Fire Commissioners. To act with the chief of the department the board appointed a consulting engineer, D. B. Banks, who in collaboration with the writer, designed the system. After the general plans had been drawn, but before the construction had been begun, the board employed two additional consulting engineers to pass upon the general features of the design. R. C. Carpenter and Frederick H. Wagner, chief engineer of Bartlett & Hayward Company, Baltimore, were chosen, and after a careful study these engineers approved the general plans and the details as far as completed. The architectural features of the station were designed by Henry Brauns, the veteran power plant architect of Baltimore. General supervision of the construction was exercised by Wm. McCallister, Jr., assistant to the consulting engineer. Before the construction work was completed, the department chief, George W. Horton, was retired, and the deputy chief, August Emerich, was promoted to the head of the department.

Contracts for the various elements of the system were awarded to the following builders and contractors:

Automobile hose wagons to the Mack Mfg. Co.

The portable hydrant heads and regulators, and the main pump governors to the Ross Valve Mfg. Co., of Troy, N. Y.

The hydrants and high pressure water pipe lines to the Pittsburgh Valve Foundry & Construction Co., of Pittsburgh. Many of the working details of the system were designed by J. Roy Tanner, chief engineer, and Charles Fitzgerald, superintendent of construction for the contractor. A subcontract for the supervision of the trenching was awarded by the general pipe contractor to E. Saxton, of Washington, D. C., one of the most experienced contractors in the vicinity on subsurface structures in city streets.

Pumps to the Allis-Chalmers Co., of Milwaukee, although this concern was not the lowest bidder. A subcontract for the 1000-gal. direct acting pump and the boiler feed pumps was awarded to the Epping Carpenter Co. of Pittsburgh.

Boilers to the Edge Moor Iron Co. of Wilmington, Del. A subcontract for the stokers, blowers and regulators was awarded to the Underfeed Stoker Company of America, Chicago.

The steam and auxiliary water piping in the pumping station to the Crook-Kries Co., of Baltimore.

The station building and harbor intake to the B. F. Bennet Bldg. Co. of Baltimore.

The signal system was installed by the department force.

NATIONAL STANDARD HOSE COUPLINGS AND HYDRANT FITTINGS FOR PUBLIC FIRE SERVICE

By F. M. Griswold

ABSTRACT OF PAPER

The paper calls attention to the enormous waste by fire each year in this country and refers to the frequent occurrence of conflagrations in various localities where the assistance called for from neighboring communities has often proved of little value on account of the lack of uniformity in fire-fighting appliances. The author makes an appeal for the early adoption and use of a practical standard coupling for public fire service use.

Specifications are given of the National Standard Hose Couplings, and several important public bodies and organizations cited which have approved this standard. Various localities are named where couplings, ranging in diameter from 3 1/32 in. to 3 5/64 in. and having 7, 7½ or 8 threads to the inch have been readily and cheaply modified to couple-up with the standard sizes by the use of a standard female ring or swivel having inside diameter of 3 1/16 in. with 7½ threads to the inch.

The paper explains the method of procedure for the conversion of couplings of various dimensions to interchange with the standard, and cites the methods actually used in several instances by the public authorities, giving data and costs.

Attention is urged to the importance and necessity of early action to secure standardization of this essential utility in use in combatting fire in public service.

NATIONAL STANDARD HOSE COUPLINGS AND HYDRANT FITTINGS FOR PUBLIC FIRE SERVICE

By F. M. Griswold,[1] New York

Non-Member

The created resources of this country are depleted annually to the enormous extent of about $250,000,000 through destruction by fire, 80 per cent of which can be justifiably attributed to preventable causes.

2 This vast fire waste serves to remove completely from the acquired assets of our people at large and from the wealth of the nation, the enormous sum of $685,000 for each day of the year, while for each minute of the day, $500 in tangible values rises in flame and smoke as a burnt offering to a veritable Moloch of recklessness, leaving only an ash-pile as its monument; thus placing a yearly burden of indirect and unjustifiable taxation at the rate of $2.65 per capita upon our 95,000,000 of population, which, if collected under process of law, would doubtless incite to vigorous public protest.

3 While a large proportion of these losses follow from what may be termed "individual burnings," where the fire may have been held within the structure in which it originated, yet by far the larger proportion is due to the spreading fires, which, getting away from the control of the local fire department, result in conflagrations of greater or lesser magnitude, and quite frequently reach such proportions as to necessitate calls for assistance from neighboring and sometimes from distant communities, in the effort to check the spread of flame which has passed beyond local control. In such cases, however, experience proves, almost without exception, that when the foreign apparatus arrives upon the scene it will not interchange with that already

[1] Genl. Inspr., The Home Insurance Co., 56 Cedar St.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

in use in some minor, but vital particular, and under these conditions, flame spreads unchecked so long as fuel to feed combustion remains in its path. Hundreds of thousands of dollars in value and many human lives are thus sacrificed as a consequence of inexcusable neglect in the standardization throughout this country of public fire-fighting utilities.

4 In corroboration of this statement may be recalled some of the notable conflagrations which have occurred within the memory of the man of middle age: Chicago, 1871; Boston. 1872; Baltimore, Rochester and Ottawa, Canada, 1904; Chelsea, Mass., 1908. In each of these instances and in hundreds of others where conflagrations of lesser magnitude have occurred, it became necessary to call for aid from the fire departments of other cities, and in each case the proffered assistance proved of little value, because of some difference in the diameter, or of the pitch or shape of the thread on hose couplings or hydrant outlets rendering them non-interchangeable with the local utilities of like character. These chaotic conditions are broadly exemplified by our records of couplings for 2½-in. hose, which show differences ranging from 2 in. in diameter with tapered iron pipe thread of 11 turns to the inch, followed by increases of diameter progressing at the rate of 1/64 in. up to 2 5/8 in., with threads varying from 6 to 9 per inch; in addition to these vagarities in threaded couplings, there are to be found several kinds of " snap " or other special or novel devices used as couplings in some localities.

5 In view of these conditions and of the too frequently demonstrated fact that the average public fire department is not so fully equipped as to enable it alone to cope successfully with a fire of conflagration proportions, and will therefore doubtless be compelled in the future, as in the past, to call upon other communities for aid in times of such emergency, it appears to be exigent that an officially recognized standard of uniformity in fire-fighting appliances and utilities should exist in every town and city of this country, especially in relation to the diameters and other particulars of hose couplings and hydrant outlets, which constitute the absolute essentials both in the means and method of conveying water in fire extinguishment.

6 It is this inexcusable lack of uniformity of these simple but vital public fire-fighting utilities that prompts the writer in the dual capacity of a member of the Sub-Committee on Fire Protection of this Society and as chairman of a special committee

on hose couplings and hydrant fittings of the National Fire Protection Association, to present an appeal for approval of the National Standard Hose Couplings and Hydrant Fittings for Public Fire Service, which have already been approved and adopted by the following important public bodies and organizations controlling or supervising the design, installation and use of such public utilities, after having been agreed upon in joint conference with their accredited representatives:

American Public Works Association
American Society of Municipal Improvements
American Waterworks Association
International Association of Fire Engineers
League of American Municipalities
Minnesota State Fireman's Association
National Board of Fire Underwriters
National Fire Protection Association
National Firemen's Association
New England Waterworks Association
North Carolina State Firemen's Association
Pennsylvania Waterworks Association
Virginia State Firemen's Association

7 It is remarkable that in this age of advancement, when every faculty of the practical man engaged in the mechanic arts is centered upon securing uniformity in practice as to the design and proportions of the various devices and appliances in general use in the field of his endeavor, that so important and universally necessary a public utility should have been permitted to escape the influence of this spirit of progress, and remain to this day a matter subject to the caprice or ignorance of those responsible for the specification and installation of such important adjuncts in public fire protection.

8 The first concerted attempt to secure the adoption of a standard hose coupling dates from the organization meeting of the National Convention of Fire Engineers, held in Baltimore, Md., October 1873, when, with the lessons before them of the great Chicago fire of 1871, and of the conflagration of 1872 in Boston, this assemblage of fire chiefs from all sections of the country, gave expression to their desire to have adopted a standard hose coupling which would serve for general use, in a resolution offered by Chief Hill, of the Cleveland, Ohio, department, to the following effect:

> Whereas, experience has shown that the fire departments of the country should be provided with a universal or standard coupling for hose and fire hydrants, so that when a city or town calls for aid, in case of large fires or conflagrations, from another city or town, that each department can act in unison with the other;
>
> Therefore be it resolved that a committee be appointed by this convention to take under consideration, and report back to this Convention the practicability

of adopting a standard coupling of some kind to be used by all fire departments throughout the United States.

9 In forwarding this resolution its proposer expressed the desire to have adopted a standard of such character, "that a line of hose might be laid from coast to coast with couplings which would permit any town on the line to tap-in." While the printed record of this convention does not give exact details of the dimensions of the standard then proposed, contemporary documents establish it as being 2½ in. inside diameter, 3 1/6 in. outside diameter over thread of male end, with 7½ threads to the inch. Accepting this standard as official, some of the chiefs upon returning to their home towns, changed their couplings to conform to these dimensions and have since maintained this standard in operation.

10 Outside of the instances noted, the matter of standardization failed of immediate accomplishment owing to the fact that no concerted and continued action was undertaken by this body of fire engineers to keep the proposition alive, who seemed content to let the resolution appear in the printed proceedings of the convention as closing the incident.

11 The matter came up again, however, at the convention of this organization in 1875, when there was adopted as its standard a coupling of 2⅝ in. inside diameter, by 3⅛ in. outside diameter, *exclusive of the thread* and of 3⅜ in. outside diameter *inclusive of the thread*, the latter to be 8 to the inch; in the 1876 convention this standard was reaffirmed, but in the convention of 1878 a special committee reported that the 1875 specifications were found to be impracticable in use, and here again the matter rested, no new specifications at that time being presented to the convention.

12 Again in 1879 the firemen submitted as their standard a coupling of 2½ in. inside and 3 7/32 in. outside diameter, with 6 V-shaped threads to the inch, which was duly adopted, but the matter lay dormant until the convention of 1883 when the 1879 specification was endorsed and resolutions were passed to secure coöperation through state legislation, and while some sporadic effort seems to have been made toward this end, nothing was accomplished which held promise of success, and the matter of legislation appears to have been dropped entirely.

13 For the period between 1883 and 1890 the question of standardization also appears to have rested, but in the latter

year renewed interest was aroused in the subject through the reading of a paper before the Firemen's Convention at Detroit, Mich., by C. A. Landy, the substance of which was based upon a letter written by John R. Freeman. A strong plea was made by him for the adoption of "a single standard thread for 2½-in. couplings, which should be universal throughout the United States." At the suggestion of Mr. Freeman, a special committee was appointed to investigate prevailing conditions as to couplings in general use, and to formulate specifications for the proposed standard.

14 At the convention held at Springfield, Mass., in 1891, the special committee made report through the chairman, C. A. Landy, showing very complete data relating to 2½ in. screw-couplings, found to be used in 1339 towns and cities of this country, showing outside diameter over thread of male end ranging from 3 in. to 3⅛ in. and including threads of 7, 7½ and 8 to the inch, and strongly advocated the adoption as a standard for 2½ in. hose, a coupling showing 3 1/16 in. diameter over threaded male end, with 7½ threads to the inch, as being an intermediary of such range and value as to insure progressive standardization at the least expense and trouble in the conversion of non-standard to serviceable interchange with it, the feasibility of such interchange being demonstrated by the use of a female swivel of 3 1/16 in. diameter with 7½ threads to the inch, into which male ends of both 7 and 8 threads to the inch were entered and formed serviceable connections; about 70 per cent of the couplings listed in Landy's report being susceptible to such adaptation.

15 The demonstrated feasibility of adapting these non-standard couplings to interchange in service with the proposed standard carried conviction to the members of the convention, and the recommendations of the special committee were adopted, including specifications for larger sized hose up to 6 in. in diameter, each of such sizes in excess of 2½ in. nominating 8 threads to the inch.

16 A resolution to print these specifications in the Proceedings served again to close the incident, and thus the solution of the hose coupling problem was permitted to rest undisturbed for a period of 13 years, or until 1904, when the great conflagration at Baltimore not only demonstrated the limits of local equipment in controlling an extending fire, but also served to bring attention to the folly of permitting continuance of those chaotic con-

ditions in relation to fire department appliances, the existence of which rendered practically ineffective the men and apparatus sent from other cities to aid Baltimore in the hour of its extremity.

17 Confronted with this record of 31 years of failure to secure the adoption and use of a practical standard hose coupling, it became evident that if success was to be the reward of further effort in this work, it could only be won through earnest and persistent coöperation between the leading organizations or other interests controlling the production of, or being responsible for the purchase, installation and upkeep of these highly important public fire-fighting facilities, and with a hope of being able to arouse general interest in this method of procedure, the National Fire Protection Association selected the writer as its delegate to the convention of the International Association of Fire Engineers held at Chattanooga, in September 1904, instructing him to propose joint action by these two organizations in a renewal of the effort to devise an acceptable and practical national standard hose coupling.

18 In consideration of the problem thus presented, it became a question whether to advise the adoption of a hose coupling thread, the specifications of which would show the extreme of mechanical strength without reference to the preponderance of designs of a less theoretical value then in general use, or to seek for the introduction of a threaded coupling the characteristics of which would most closely accord with the majority class, and at the same time prove to be an intermediary of such capacity as to accommodate itself to interchange with a large proportion of couplings not exactly conforming to its dimensions.

19 Accepting the latter method of procedure as promising the widest measure of success, the committee of the National Fire Protection Association undertook a special investigation of existing conditions, using the Landy report of 1891 as a basis, and after securing such additional data and being convinced of the practical value of the specifications named in that report, submitted as a standard coupling for 2½ in. hose, one showing a diameter of 3 1/16 in. over male and thread with 7½ threads to the inch, by the use of which it was practically demonstrated that couplings ranging in outside diameter from 3 1/32 in. to 3 5/64 in., with either 7, 7½ or 8 threads to the inch, could be so modified as to couple-up in service with this suggested stan-

dard, and thus render over 70 per cent of the 2½-in. couplings known to be in use, conformable to the proposed standard at small expense as to time, money or labor.

20 In elucidation of the essential features of this standard it was deemed wise to formulate specifications covering 2½, 3, 3½ and 4½-in. hose couplings, the inside diameters of which were to be in conformity with the sizes named, specific details relating to each of the standard sizes being shown in the printed specifications as follows:

Inside diameter of hose, in.	2½	3	3½	4½
Number of threads per in.	7½	6	6	4
Male Couplings				
Outside diameter of thread finished, in.	3$\frac{1}{16}$	3⅝	4¼	5¾
Diameter at root of thread, in.	2.8715	3.3763	4.0013	5.3970
Clearance between male and female threads, in.	0.03	0.03	0.03	0.05
Total length of threaded male end, in.	1	1⅛	1⅛	1⅜

The above were to be of the 60-deg. V-thread pattern with 0.01 in. cut off the top of thread and 0.01 in. left in the bottom of the valley in 2½-in., 3-in. and 3½-in. couplings, and 0.02 in. in like manner for the 4½-in. couplings and with ¼-in. blank end on male part of coupling in each case. Female ends were to be cut ⅛ in. shorter for endwise clearance. They should also be bored out 0.03 in. larger in the 2½ in., 3 in. and 3½ in. sizes, and 0.05 in. larger in the 4½ in. size in order to make up easily and without jamming or sticking.

21 The printed specifications for the national standard coupling include full sized working drawings showing the details of the various dimensions above noted, and in addition contain matter descriptive of the method of procedure for converting non-standard couplings to interchange with the national standard in service, and also cover the matter of standard fire hydrant fittings. Copies of these specifications may be had upon request.

22 It may be well to explain that 2½-in. hose is the size in most general use by public fire departments for their leading lines; and it is in this size of hose that the most marked diversity in the character and dimensions of couplings is to be found; the 3 in. and the 3½ in. sizes being mainly used for high-pressure or fire-boat service, are not in such general use, but the specifica-

tion for six threads on couplings for this service conforms to general practice in relation to these sizes. The dimensions specified for the 4½-in. engine suction hose are necessary to conform to the capacity requirements of the standard fire hydrant, which shows a 6-in. barrel fed through a six-branch line from the street main. The nomination of four threads to the inch on the suction hose is in conformity with the general practice of fire engine builders, and is known to the trade as the "Amoskeag thread."

23 Having come to this decision, the committee, bearing in mind the failure of past efforts because of the lack of coöperation between the interests vitally concerned, sought the advice and coöperation of organizations having control or supervision of the installation of these public utilities. To that end the matter was taken up with the several organizations already mentioned as having adopted the standard, and the details of specification as above presented were critically considered and accepted by each without change, as being of such practical utility as to warrant the general adoption of the National Standard Hose Coupling.

24 When this proposition was first presented for acceptance, the committee which the writer represents held data relating to coupling dimensions in about 1600 separate localities in this country, but since that time it has created a card index record containing data from some 3133 towns and cities in the United States and the Dominion of Canada. This record is believed to be as nearly accurate as can be expected in a work of this character and magnitude. The data were carefully compiled from ten separate sources of information, including signed statements from fire chiefs and waterworks managers, transcripts from the tabulated record of coupling dimensions prepared by John R. Freeman in 1892, and from official records of many manufacturers of hydrants, hose or other fire department apparatus, supplemented by reports of the engineers employed by the various insurance inspection organizations.

25 Analysis of the data shown in this record, based upon actual results accomplished in the conversion of non-standard couplings safely to interchange with the established standard, demonstrates that approximately 80 per cent of the couplings listed are either of standard dimensions or may readily be modified so as to conform to them, without necessity for replacement,

while the cost of conversion or replacement has been practically demonstrated to be so small as to be almost negligible in the accomplishment of this very essential change from chaos to uniformity in public fire-fighting utilities.

26 In evidence of progress in this work, the record shows 73 cities or towns in which the national standard has been put into service, either as new equipment, or by adaptation of non-standard couplings to interchange with the standard, while seven installations include the complete substitution of national standard hose couplings and hydrant nipples in place of previously prevailing non-standard devices, under such conditions as to methods of procedure and cost of substitution warranting brief mention. Notable among these are the city of St. Louis, Mo., the pioneer in the active promotion of standardization, where over 11,000 hydrant outlets and the couplings on many thousands of feet of fire hose were changed from a so-called "bastard" six thread to the standard, all of the work being done by city employes, at an average net cost of $1 per hose coupling, and of $2.82 per hydrant outlet, the latter being principally of 4½-in. steamer suction type, each of which was laboriously chipped-out by use of a cold-chisel.

27 Closely following this action by St. Louis, the city of East St. Louis which lies on the opposite shore of the river in Illinois, brought its equipment into conformity with that of the larger city upon which it must call for aid in time of threatening disaster.

28 During the winter of 1910-1911, the city of Springfield, Mass., discarded the "universal clutch" coupling and substituted for it the national standard, changing 1350 hydrants, some of which had four outlets, at the rate of from 50 to 100 outlet replacements per day, at an average net cost of $1 per outlet, giving credit for the old metal, sold at 9½ cents per lb., and excluding cost of labor performed by the regular force of water-works employes. Couplings on 22,000 ft. of hose were changed by department employes at a like net cost of $1 each.

29 It is interesting to note that this work at Springfield was carried out in the winter season, and that it was accomplished without accident by the use of surprisingly simple and expeditious methods, in that, where hydrant nipples were leaded-in, the use of a 6-lb. sledge proved an efficient means for their removal, while in the case of screwed-in nipples, an expanding

wrench, entered from the out-board end of the nipples engaged the operating lugs and permitted the easy removal of the device, while the 4½-in. leaded-in suction nipples were melted out by the use of a plumber's gasolene blow torch, at the rate of 5 min. per operation. This practical and unique demonstration of "how to do it" is commended as being worthy of serious consideration.

30 Following this action at Springfield, the contiguous cities of Chicopee, Holyoke and West Springfield, each brought their equipment into conformity with the standard, at an expense probably no greater than was that of the change at Springfield.

31 Shreveport, La., replaced the old-time "Feyh" coupling by installing the standard, but there are no data as to method of procedure, nor as to the cost of the operation.

32 In the cases of many other towns and cities which are known to have adapted non-standard couplings to interchange with the standard, the work has been accomplished entirely by the regular force of public employes, and outside of the time used the expense has been nominal, at most involving the cost of an adjustable tap and die, conforming to the pitch of the non-standard thread, by the use of which these couplings were so modified as to become readily interchangeable with the standard; citations of the following instances being illustrative:

33 Atlanta, Ga., used both 7 and 7½-thread couplings for years without serious trouble from these differences, but now uses the standard only. Watertown, N. Y., in changing to standard discovered three kinds of hydrant outlets, varying both in number of threads and in outside dimensions, all of which have been made to conform to the standard without other cost than the casting of a die, as stated by the chief of the fire department.

34 This list could be materially enlarged by naming many other towns of less prominence, which are known to have brought their equipment into conformity with the standard, while from information not yet verified, it is believed that a number of other localities have taken like action. In addition our record shows the installation of the standard in 122 localities not so listed at the date of the last issue of the Record in 1911, and as an evidence of the widespread interest aroused in this important matter of standardization, it may be stated that one prominent concern manufacturing fire hydrants, reports having filled orders for hydrants under national standard specifications for

some 46 separate towns and cities, included in which number may be named Montreal, Port Hope, St. Anne and St. Joseph in the Dominion of Canada, and the town of Aibonito, in Porto Rico.

35 The writer has models which demonstrate the practicability of so modifying either a 7 or 8-thread coupling as to produce a perfectly reliable connection when a 7½-thread female swivel is used as an intermediary or accommodator to complete the joint.

36 The technical explanation of this seeming mechanical anomaly will be readily appreciated from the fact that threads having a V-shaped section possess the property of adjustment in relation to the accommodation of other threads of like shape, but which do not conform exactly in pitch, and which can yet be made to fit closely enough for all practical purposes. The property in question relates to the clearance between the threads, and is strikingly illustrated in making ordinary nuts, bolts, and screw joints, where clearance is required and utilized to secure a practical fit in the joint without dependence upon absolute accuracy in workmanship.

37 Keeping in mind this property of the V-shaped thread in making a comparison of the difference in clearance between 7, 7½ and 8 thread pitch, it becomes evident that with a thread of 7 turns to the inch, the space between the crests of the threads will be 0.1428 in., while in the case of the thread having 7½ turns to the inch its crests will be 0.1333 in. apart, and that with 8 turns to the inch the crests will be 0.1250 in. apart; hence, in selecting this standard of 3 1/16 in. outside diameter, with 7½ threads to the inch, it will be found that by reducing the diameter of the threaded male end or increasing the inside diameter of the female ring or swivel by a fraction of an inch, the first crest of the modified male thread will fit into the valley of the 7½ thread female ring, and that while in the progression of the spiral the following crests will not be exactly coincident with the corresponding valleys, the normal differences of clearance will be only 0.0083 in. for the 8 thread, and 0.0095 in. for the 7 thread, or less than 0.001 in. in either instance, while the reduction in diameter will be sufficient to prevent clashing of the inclined surfaces, and thus permit a fit with practically as good contact throughout the joint as if these modified threads were

of the same pitch as that of the female ring into which they are entered.

38 The foregoing facts show how cheaply and easily complete standardization may be secured. No competent mechanic can offer a valid objection to the standard as specified. It is not patented, nor is it patentable; it is but a simple adoption of common present means toward the elimination of present indefensible conditions, which continually cry aloud for the abolition of the incompetence, ignorance and carelessness which now control the selection and installation of these vital public utilities, the standardization of which is of transcendent importance.

39 Manufacturers of hydrant and other fire department apparatus will hail with gladness the day when any order for such adjuncts could be safely executed by compliance with specifications demanding conformity to the national standard, thus enabling them to discard the hundreds of couplings templets now cumbering their shelves.

MEETINGS IN BOSTON

At the regular monthly meeting of the Society held in Boston, November 15, 1913, Frederick J. Hoxie presented a paper on Dry Rot in Timber used in Slow-Burning Construction; at the meeting on December 20, H. W. Hayward read a paper on The Testing Laboratory and the Constructing Engineer. The papers, together with the discussion on each, are given herewith in abstract form.

DRY ROT IN TIMBER USED IN SLOW-BURNING CONSTRUCTION

By Frederick J. Hoxie, Phenix, R. I.

Member of the Society

ABSTRACT OF PAPER

The old idea of the phenomenon of rotting in wood was that it was an oxidation process similar to the corrosion of iron. It was shown about 35 years ago that it is a direct result of fungus.

Though in the past fungus attacks have not been sufficiently frequent or destructive to attract much attention in this country, in Germany laws have been passed relative to the sale of buildings infected with it. But even in this country poorer lumber is being used each year in factory construction, and it is rare that a pile of timber to be used in a new mill does not contain at least several sticks of North Carolina pine, mostly sap wood. In mill buildings beams infected by fungus frequently give no warning of their diseased condition until the interior is nearly destroyed. A skin of sound wood from ½ in. to ¾ in. thick is left on the surface, which quickly burns through and the building falls, as in the case of the Gledhill Wall Paper Factory, New York City. It is important therefore to define clearly and unmistakably the

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Presented at the Boston Meeting, November 15, 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

qualities of wood to be used in construction in the specifications. Simple identification by a botanical name is not sufficient because it expresses no essential quality of the material, and after a tree is sawn into lumber and shipped to a distant point it is impossible to determine from what particular variety it came. Not only is a clear understanding of the essential chemical and physical properties of the timber necessary, but also a careful consideration of its disposition in the structure. The damaging effect of a heavy coat of paint or metal covering on moist wood must also be considered, since with material of doubtful quality such treatment would be dangerous and with the best of material imprudent.

Double beams and bored columns have been used extensively in mill construction to prevent dry rot and checking in the columns as well as to make a large beam of two or more smaller ones. From a quotation in the Engineering Record[1] it appears that many mill engineers have found this of little value in preventing fungus diseases. The holes in columns as generally found are of little value in preventing checking, as comparatively few are at the center of growth of the tree. The circulation of air is so slight that the holes, instead of preventing fungus growths, encourage them. The openings between beams when covered to keep out fire also make attractive places for fungi if sufficient moisture is present, while the vertical holes when not stopped by continuous iron plates afford excellent passageways for dangerous fungi from floor to floor in a factory building.

In hard pine timber resistance to water is related to resistance to fungus and in sound hard pine, resistance to water is a function of the amount of rosin it contains. Thus it is a well-known fact that hard pine heart wood is more resistant to dry rot than sap wood. Injury to the tree or unfavorable changes in its environment may also cause abrupt change in the quality of the wood and its power of resisting fungus. The author arranged an experiment to determine whether the rosin in long-leafed pine heart wood was an important factor in resistance to fungus. A cubic block of dense fine-grained wood 2 in. on a side, containing 18 per cent rosin, was sawed in two across the grain, and half of it was boiled in benzole until practically all the rosin was removed. The solvent was driven off, and a piece of wood containing living dry rot fungus was placed between the two blocks.

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[1] Vol. 61, p. 315.

The whole was placed in a moist atmosphere and the fungus allowed to grow for a year, at the end of which time a dense white growth had formed over each block. This growth was removed, the blocks dried and weighed. The specimen from which the rosin was removed had lost 8 per cent, the other only 2 per cent. Neither showed the brown color characteristic of rotten wood until after they had been dried for some time.

There are many varieties of fungus that attack wood. The true dry rot fungus, *merulius lacrymans*, is not as common as several other varieties which require a better water supply, but can remain in dry wood in a resting state for a long time, variously estimated at from 4 to 40 years, ready at any time when the wood is sufficiently moistened to start out in active growth, and according to some investigators when once started is able to provide its own water supply from the decomposition of the wood, if the evaporation is not too rapid. The disease is highly contagious and will rapidly spread from infected to sound wood.

Mr. Richard Falck[1] has shown that the thermal death point of *merulius lacrymans* and several kindred varieties is low, less than 100 deg. fahr. This has a practical application in that these fungi may be destroyed in many cases by use of the building heating system, and an experiment on a large scale in a badly infected mill goes to show that this cure can give good results, if applied soon enough; it does not, however, affect the growth of fungi in ends of beams in the brick wall where the heat does not readily penetrate. When there is any question as to the quality of the stock used in a building, heat is worth trying, and it should be done as soon as possible after the building is completed. When fungus begins to show, it is generally too late to save the affected parts.

Several of the more common fungi which destroy basement floors, fence posts and railway ties are the Lenzites and members of the Polyporus family. The Lenzites are, according to Falck,[2] capable of resisting temperatures up to the boiling point of water. These and the dry rot fungi have strands sometimes several feet long and capable of traveling for some distance across masonry or metal from beam to beam. Several varieties of microscopic molds grow readily on moist wood. H. Marshall

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[1] Hausschwamm Forschungen, vol. 1, p. 53, Dr. Falck.

[2] Hausschwamm Forschungen, vol. 3, 1909.

Ward[1] has suggested the possibility of common green mold *penicillium*, acting as a wood destroyer, and there is a black mold, which does considerable damage to moist woodwork about paper mills and weave rooms, but acts more slowly than dry rot, and requires about eight or ten years to destroy a 3-in. roof plank.

Fungus is undoubtedly frequently spread by piling infected lumber with sound but susceptible material, the sticks used in lumber piles for separating the boards being a frequent source of infection. Air circulation in large piles of lumber is not sufficient to destroy the fungus, or indeed to prevent it from spreading from diseased to sound material, and the expense of a reliable antiseptic can be offset in several ways: the value of wood saved, greater economy of yard room and less expense for high piling; better insurance risk, in addition to the fact that the material manufactured from lumber so treated would be more reliable.

If fungus is found growing in a building, a careful investigation as to the extent of its ravages would be advisable. Heating and poisons can be used to destroy superficial or scattered small infections, but wood contaminated to any degree had better be removed. Fungus infected wood is more readily combustible than sound wood, and will hold fire longer. This is probably caused mostly by the better air supply in the punctured cells; another contributing cause may be waxy substances contained in the fungi. A danger from this source is that infected bearing ends of beams and columns may be burned away rapidly by a slight fire.

Diseases of timber like diseases of men have excited more interest in cure than in prevention. It is generally admitted that a building badly infected by dry rot is a difficult problem. The effectiveness of the most elaborate remedies is doubtful. Drying has been widely recommended, but can only be used where the occupancy does not involve moisture. Heating is undoubtedly more efficient where the dry rot family of fungi is concerned, but both drying and heating are uncertain with large beams or beams built into walls and deeply infected. Beam ends in walls not infrequently receive moisture from the wall and form a favorable place for fungus growth where it is difficult to detect it. Chemical curative treatments such as poisonous vapors and liquids have unquestionable value for local attacks, but are of little use if the disease has become widely distributed, and it is difficult to determine how far it has extended.

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[1] Annals of Botany, 12, p. 565, 1898.

Prevention is by far the best procedure, and much work has been done along this line on railway ties, telegraph poles, etc. Numerous antiseptic compounds have been suggested, creosote compounds and chloride of zinc being probably more commonly used than any others. Creosote, however, is objectionable in buildings owing to its black greasy nature, its somewhat increased fire hazard and disagreeable smell. The kyanizing process of treating timber with corrosive sublimate solution has been used more or less frequently with good results. Although its cost, corrosive qualities and poisonous nature have probably operated to prevent its more general use, it appears to be well adapted to treatment of factory lumber. Chloride of lime appears to encourage the disease rather than remedy it. The season for cutting timber seems to have only a secondary importance, but the dryness of the wood, whether the moisture be sap or rain water, is an important factor. Preserving timber under water prevents fungus growth while the material is in storage, as fungus cannot grow without an air supply. It may also have some benefit in dissolving from the outer parts of the wood where infection must start some of the nitrogenous constituents which serve as food for fungi. Further investigation is however needed along the line of the chemistry of seasoning and heart foundation.

Quick growing timbers will continue to come into more general use owing to their more rapid reproduction. The author's experiments would indicate that hard pine, to be able reasonably to resist fungus in building construction without antiseptic treatment, should contain about 10 per cent of rosin. Artificial saturation of wood with rosin has been tried without very satisfactory results, owing to the lack of penetration. It should not absorb over 5 lb. of water per cu. ft. in 24 hours at 70 deg. fahr. from kiln dry condition, and should weigh not less than 38 lb. per cu. ft. kiln dry. These characteristics generally accompany fine grained material, and with them fine grained material is better than coarse grained, while without them the fine grain does not appear to be a saving quality.

DISCUSSION

Chas. T. Main told of a case in his practice showing the disastrous effects of painting lumber when green. In 1872 a mill was built; the lumber was cut in the South, loaded on cars, installed as quickly as possible after its arrival and immediately painted. The timbers were white pine, the planking hemlock, and the posts oak; no heat was put on the building for some time, until after the machinery was put in. Four years later it was found that the planking was all gone; the timbers were rotted down 3 or 4 in. as well as the oak columns in the first story. The only thing that was holding the floors was the upper floor of Southern pine. Since then his company always specified that painting was not to be done until after the timbers were thoroughly seasoned, generally in a year or two. Unless there was a free circulation of dry air, floors would not last long. They were softened and weakened by being constantly wet, and would decay when subjected to wet and dry alternately. If exposed to dry but confined air, they were liable to dry rot. The most efficient method of preserving timbers was to have them well seasoned and exposed to a free circulation of dry air.

The treatment of timbers and planking to be exposed to dampness was quite common practice. Mr. Main had used with good results a great deal of kyanized planking for floors which were resting on the ground, as well as in dye houses where the ceiling or roof was exposed constantly to the hot vapors rising from the kettles. He had had occasion to investigate the condition of treated lumber which had been subject to unfavorable conditions and had found it in excellent state of preservation after many years' service.

The application of cold water paint or creosote paint did not appear to have any disastrous effects upon timber, but the application of oil paint which sealed the pores, would cause dry rot if the timber had not been well seasoned before the paint was applied.

The speaker's practice for preventing checking of wood columns was to build cast-iron wall boxes with an air space around them, and in these to rest the ends of the timbers.

E. F. Miller asked as to the method of testing beams by drilling a hole into a timber and filling it with bichloride of mercury and alcohol. Mr. Hoxie said he could tell better about this method when some experiments on which he was at work were completed.

Some students at the Massachusetts Institute of Technology had conducted tests by the absorption of water method, but it was a long process and not practical. To prevent moisture from getting into the timber, creosote preparations were sometimes applied with a brush; poisonous salts had no power to keep out the dampness, but served to destroy fungus growth. The rosin process had possibilities, and it seemed to the speaker that it was a failure because it was put on too thick.

R. A. Hale[1] stated that his company used a liquid called carbolinium with good results. It was put on with a brush.

Dwight Seabury added that he had used carbolinium in a jewelry factory in Providence, and that it had soaked through the maple floors.

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[1] Essex Co., Lawrence, Mass.

THE TESTING LABORATORY AND THE CONSTRUCTING ENGINEER

By H. W. Hayward,[1] Boston, Mass.

Non-Member

ABSTRACT OF PAPER

The many grades of materials now obtainable make it necessary to have definite specifications for everything. These specifications must be fair to both dealer and purchaser, and no more rigid than is necessary to obtain the quality of material required. Unnecessarily rigid specifications are apt to cause friction and usually boost the price excessively; and often they are not lived up to. A set of specifications should be so drawn as to insure the delivery of the exact quality of material desired and leave the manufacturer as much leeway as possible. The engineer should be familiar with the processes of manufacture in order to select the tests that are made with the special object of determining the care used in their manufacture, and the manufacturer should be familiar with the uses to which the materials are to be put. The two can be brought together by common interest in a testing laboratory where the qualities of the materials can be determined, and tests made upon full sized specimens.

There are several kinds of laboratories for physical tests of structural materials: single testing machines in works; works laboratory, special and complete; testing company's laboratory; government; and technical schools. A single testing machine in a manufacturing plant is usually operated by an unskilled man, and shows as a rule only one quality of the material tested. Works laboratories vary considerably in scope and capacity, some of them being very complete as regards the special requirements of their respective

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[1] Assoc. Prof. Applied Mechanics, Mass. Inst. Tech.

Presented at the Boston Meeting, December 20, 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

works. While being of great assistance in controlling the processes and quality of the materials produced, they do little work in any other direction. The men operating them are usually not of a high order of intelligence, and even the men in charge are sometimes rather narrow in their views and consider the makers' standpoint only. A few large companies maintain laboratories conducted by most skillful and capable men who carry on work along all lines connected with the industry and obtain valuable data, many of which are published for general information. Private testing companies do splendid work for their clients. The government has extensive testing laboratories equipped with all necessary apparatus, and is doing very elaborate research and service work. The work is carried on, however, very slowly, and no results are published until the investigation is complete in every detail. The work is done primarily for the government and private individuals must untangle a great deal of red tape before anything can be done for them. The Bureau of Standards should furnish the profession with a standard method for testing the accuracy of testing machines.

The laboratories of technical schools fill in a wide gap. In them an equipment of great variety is usually provided to satisfy the requirements of tuition, thesis work and research. In addition, technical school laboratories must be prepared to carry on commercial tests at all times, and much could be done in this connection if engineers could be persuaded to put more of their questions up to technical school laboratories at the proper time for thesis work.

The specimens for the tests to determine if a material passes specification must be properly selected, must be of the required size and shape and taken from the proper place. As a matter of fact, specimens are often submitted in an entirely unsatisfactory manner, e. g., just 8 in. long when it is required to determine the elongation in 8 in., no extra length being left for the grips of the testing machine. For testing properly the ratio of diameter to length, sufficient metal for unrestricted flow should be maintained, if elongation tests are to be considered and correct values obtained. In spite of this, one of the government specifications for a test specimen for bronze or brass castings is 1.128 in. diameter by 2 in. long in the cylindrical part, which is too short for ductility determination.

The condition of testing machines must be thoroughly watched. The weighing system is often out of order and the heads may be out of line; the latter has a great effect on short brittle specimens, such as cast iron, where the eccentric load causes a much lower strength to be recorded than is the actual case. The screws for the buffers should also be watched.

On the whole, specimens should be tested in a manner to bring out the care in the manufacture of the material, and to show any inferior quality from any source. No unnecessary tests should be specified. Some tests usually left out of specifications are in the opinion of many engineers and manufacturers more valuable than many of those that are included, e. g., reduction of area in ductile materials, especially for high grade steel or wrought iron, instead of elongation only. Twist tests for copper wire belong to the same class. The tests specified must be as simple as possible so that they may be carried out in any fairly equipped laboratory at a minimum expense. Quantitative tests for the specifications of manufactured parts, columns, girders, slabs, pieces of machines, etc., are a much more difficult problem than the qualitative tests of materials from which they are fabricated, and can be made only by laboratories well equipped with apparatus and force. These tests must approximate working conditions as nearly as possible and must furnish data for the design of the parts.

It is encouraging to note that many engineers and manufacturers are taking up with great enthusiasm the question of testing parts of machines and structures or even complete machines, and are successfully standardizing their products. Many engineering firms with the help of testing laboratories are getting up specifications covering the complete line of materials used by them, effecting thereby a great saving in trouble and money. Much, however, remains to be done.

Many terms used in connection with structural materials are in a rather mixed state, such as elastic limit, yield point, strain, etc. Quantities that cannot be obtained exactly, e. g., elastic limit or yield point of copper or bronze, should not be specified.

New qualities of materials are being continually brought out which require special tests. This is especially true with regard to the compound steels and alloys which are being used for shafts, gears and other parts of running machinery. To determine their value such metals must be tested for repeated stress and shock resistance. About 100 letters were sent to prominent manufacturers and engineers in the United States by the Massachusetts Institute of Technology, but the answers brought nothing but a mass of variable and conflicting data, and it is still undecided just how to go to work on this subject, as regards both machines and specimens.

The variation in quality due to treatment in these high grade steels and in many alloys, make chemical tests, though of value in some cases, almost useless in others.

The author gave the following interesting information: ductile material elongates when twisted; modulus of elasticity of piece of high carbon steel is the same as for soft, within the elastic limit; a crystalline fracture on soft rivet steel can be obtained by gradual tension; steel of great strength may be very ductile; fiber rope can be made to break in the center if held by eye splices properly made and wet; steel or copper cable can be broken if held in cast sockets; best rivet steel can be nicked and bent without cracking open.

DISCUSSION

Ira N. Hollis spoke of his experiences in inspecting material for the government. One of the chief difficulties that had to be contended with was interference with inspecting officers by Congressmen. In 1885, when he was inspector for the Naval Board on Ships, he rejected a lot of shafting. The entire delegation from New Hampshire and Massachusetts in Congress appeared before the Navy Department and stated that this shafting must be accepted. It was finally accepted on the condition that the torsion test should come within the elastic limit; but what was the elastic limit? Finally the shafting was tested for torsion and snapped at a load considerably below the requirements. But for the expensive method of testing, it would have been put in the ships. The inspector's report on the process of manufacture is of more value than testing of sample pieces. Investigation of full size pieces in structures in actual buildings would be a good thing. For instance, shafting in ships has never the same stresses as when it is in the testing machine. The speaker once visited the engine room of the steamer Paris, and noticed that the difference in level between the bow and stern as distinguished from the body must have been more than an inch. What effect that has on the shafting is not clear. Professor Hollis, as assistant on the Advisory Board, wrote the first steel specifications for the Navy, and it has been said that the enforcement of these specifications has done much for the steel industry in general.

George F. Swain admitted the value of testing, but expressed a belief that there was a tendency to do too much of it than too little. In some cases the specifications of certain physical properties of the material may be sufficient, but in others, such as that of concrete, the process of manufacture must be especially considered. Results of tests must be used with a great deal of care.

C. E. Woods[1] spoke of trolley wire testing. The earlier users assumed that the harder the wire, the longer it would wear, and the specifications were to the effect that the manufacturer should draw the wire as hard as he could. It is only within the last few years that it was discovered that for one break due to tension there were 100 breaks due to repeated stresses, that is, the bending effect at the ears or other fixed points caused by the sudden stopping of the wave-like motion imparted to the wire by the trolley wheel. The new specifications therefore dwell more on repeated stresses than on tension. Generally speaking, the manufacturers today realize that there is a limit to the amount of money that will be paid for the various kinds of engineering materials, and act accordingly. A manufacturer at the New York meeting of the International Rubber Congress expressed this feeling when he said to a representative of one of the great American railroad systems, who complained of the comparatively poor quality of the air-brake hose his railroad was getting, "when you send your purchasing agent to get bids on hose, tell him to say that you want the best air-brake hose that can be purchased; but when you tell the manufacturers that you will pay so much, you will get the best thing there is for that money."

[1] A. D. Little & Co., 93 Broad St., Boston, Mass.

INDUSTRIAL MANAGEMENT

At the Annual Meeting of the Society in December, the Sub-Committee on Administration presented for discussion majority and minority reports reviewing the present state of the art of industrial management. These reports were printed in the November issue of The Journal. The discussion required two sessions, occupying one whole day at the Annual Meeting, and is here published in condensed form.

DISCUSSION OF REPORTS OF SUB-COMMITTEE ON ADMINISTRATION ON THE PRESENT STATE OF THE ART OF INDUSTRIAL MANAGEMENT

Charles B. Going expressed the view that there was a lack of correspondence between the title and the substance of the majority report. His impression from reading the report was that, after an introductory attack upon the analysis of the elements of industrial management, it proceeded to argumentation on its own behalf and presented, not a survey of the present state of the art of industrial management as it exists in this country, but an interpretation of a theory of management as it exists in the convictions of the majority of the committee. He did not intend to depreciate the interest of the conclusions expressed by the majority of the committee, but only to point out that these do not constitute a report on " the state of the art of management," and that they give us no more than a fragmentary idea of the conditions under which this art is carried on in the United States to-day.

A most commendable stand is taken by the committee in using the term "scientific management" descriptively, and not in the titular sense, applicable only to the Taylor system, in which it

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

has often been employed. Scientific management should mean, as the committee says (Par. 36), "management using scientific methods, these being taken largely from the sciences of physics and psychology." But even with this definition in mind, the committee appears to have limited its views too closely to questions of physics and to have given inadequate attention to the questions of psychology, which, in the estimate of many students of the subject, are really paramount in the art and practice of industrial management.

Scientific management, using the term now in its titular sense, offers one method of finding standard individuals. There are other methods, forming no part of the systematic ritual of this school, which are stated to be far more effectual in discovering and distributing standard individuals. There are policies or methods of much interest, designed to better the conditions of operation with the apparently large numbers of non-standard or sub-standard individuals by whom so much of the work of industry is now carried on. Quantitatively, these schools of thought and of practice are of much importance in the existing state of the art of industrial management. The Taylor system is but one factor. There is much valuable contribution to thought and practice outside of the list of publications published in the Transactions of The American Society of Mechanical Engineers, and listed in Par. 66.

By leaving this apparently out of its consideration, and concentrating its attention upon a single factor instead of analyzing the entire equation, he thought the majority report of the committee was but another contribution to an already overburdened controversy, and that it had left the general survey not only unfinished, but scarcely even begun.

Halbert P. Gillette, while able to subscribe to many of the statements of the report, took exception to the statement that "This paper (Shop Management by Fred. W. Taylor) with the subsequent writings of the author stands today as the only comprehensive outline of industrial management."

Mr. Taylor's admirable paper on Shop Management and his subsequent writings (which are all restatements of the principles given in that paper) are so far from being a "comprehensive outline of industrial management" that one needs but to contrast the four "Taylor principles" of management with the twenty or more principles that have already been formulated to recognize that Mr. Taylor has confined his writings to a very narrow, though very important class of industrial management principles.

In 1908, in conjunction with Richard T. Dana, the writer prepared a series of lesson papers entitled Cost Analysis Engineering which were published in book form and in which appears what the writer believes to be the first use of the term "science of management." In that book six principles of management were formulated.

In 1909, Cost Keeping and Management in Engineering, by Gillette and Dana, were published and dedicated to Fred. W. Taylor. This book contains an execution of part of the writer's original idea of writing a philosophy of management. Ten laws of management are formulated in this volume and seventeen rules to be applied in managing construction work are given, several of which the authors have in subsequent writings expanded into broader generalizations which may be termed laws of management. Since writing these books the authors have prepared a considerable number of articles formulating other laws of management, such for example as the law of plant location, the best illustrations of which may be attributed to the late A. M. Wellington, whose book on The Economic Theory of Railway Location (1887) is one of the most profound expositions of the application of one law of management which has ever been written.

The writer desires to take no credit for the pioneer work of other men, and has always tried not to be derelict in giving credit. But for such credit as may attach to the attempt to write a comprehensive "science of management" he does lay claim to priority.

While to mechanical engineers belongs much of the credit for having written discussions of the principles of management, the writer believes that members of this Society have often made the serious mistake of supposing that the whole of the science of management has come within their discussions. They have quite generally overlooked the work of such giants in the civil engineering field as the late A. M. Wellington. It is true that Wellington did not write about the direct handling of men, but he so wrote about one phase of the indirect handling of men, if it might so be termed, that he is justly entitled to place as one of the greatest authorities on management engineering. Others before him have applied the principle of capitalizing operating expenses to determine which of two plants or machines is the most economic, but he applied this principle so minutely and so extensively as to revolutionize the practice of railway location. Indeed, he converted the art of railway location into a science by the application of one principle of the science of management.

The science of management embraces far more than the direct handling of men or the timing of the operations of men and machines. These may be scientific management as far as they go, but they do not comprise a science of management.

The science of management is a comprehensive code of demonstrable and formally enunciated laws for so directing the energies of men as to secure the most economic production and marketing of utilities.

The whole science of management usually covers five fields: (*a*) Directing the planning of the plant; (*b*) Directing the building of the plant; (*c*) Directing the operation of the plant; (*d*) Directing the purchase of materials and supplies for the plant; (*e*) Directing the marketing of the products of the plant.

The papers on scientific management that have been read before this Society have related, almost entirely, to the third field mentioned.

In developing a science of management, it has been the aim of Mr. Dana and the writer to apply the inductive method of logic in a thorough manner. The methods pursued by successful business men in all lines of endeavor have been collated and analyzed, the object being to draw sound generalizations from the data thus gathered. The generalizations drawn from these data have been called " laws " or " principles " of management. This is a process that has no kinship with the invention of a new system of management. An invention, which may consist in a new combination of several old principles, is not a science and never can be properly designated as such, no matter how far reaching are the economies effected thereby.

It seems to the writer that the public in general, and even the engineering public, has thus far failed to perceive the difference between what is scientific and what is a science. Failure to recognize the fundamental difference between what is a part and what is a whole, has led to extravagant claims for the part and consequently will lead to derision of claims that may now be properly made for the whole. Such is the potency of words that many of the most serious errors arise solely because words are not strictly defined and strictly used according to definition.

A. Hamilton Church.[1] Of the two reports presented by the committee, the minority report raises the question as to whether the claims of certain groups of men, that they are in possession of the key to all progress, has any measure of justification.

As it appears to me, the various schools of management have not presented to us any well-balanced theory of management capable of being developed in a hundred different ways according to special needs. On the contrary, it is as if they had presented to us a barrel of gunpowder, a telescope, and a magnetic compass and claimed these mechanisms to be the whole science of maritime warfare. Certain definite and concrete mechanisms such as planning departments, stop-watches, despatching boards, instruction cards of extraordinary complexity, and special methods of remunerating labor are interesting and useful, but they do not make, either singly or combined, a science of management.

Moreover, the original claims, already generously broad, have been so expanded by some of the younger disciples that almost every modern method is claimed to be the direct outcome of the wisdom of one or another of the rival schools of scientific efficiency, and I am not at all certain but that some of the more enthusiastic young men claim that electric lighting in the factory is due to the new principles of scientific efficiency.

It is because this kind of thing has become rather notorious that the minority report is important. It would be a pity, if by inadvertence, the Society should appear to set the seal of its approval on the campaign of exaggeration that has been somewhat widely carried on in the public press and elsewhere.

Turning to the majority report, we find that the prime underlying principle of management engineering is the transference of skill. This is an illuminative statement, and I venture to think, of great practical value. It is put very tersely in the sentence in Par. 8, “the skill in shoemaking is now in the mechanical equipment of the shop.” That is a clear-cut picture of a change that is already complete, and it helps us to realize exactly what is meant by the transference of skill. It also helps us to understand why, in the engineering trades, there are such wide discrepancies in the amount of work turned out by individual operators. It is because, in these trades, the transference of skill is by no means so complete. For one thing, the capacity and range of the average machine tool is large, and to some extent indefinite. A considerable amount of skill is still vested in the worker. Still more, a remarkable amount of ignorance as to what the machine will or will not do is shared by the employer and the workman.

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[1] Cons. Engr., 30 Broad St., New York.

The report shows why this is bound to be so at the present stage. In the process of transfering hand skill to the mechanical fingers of the machine, the report emphasizes the fact that more attention has been devoted to designing it, than to the problem of using it afterwards. It has been overlooked by the masters of industry that most machine tools are not specific but general machines, and that therefore a continuous study of the capacity and use of the machine is necessary to give effect to the skill stored up in it.

The more I think over this problem, the more I am convinced that the true line of progress is the exhaustive study of machines, their capacities and limitations. I have held this opinion for many years, and the system of industrial accounting I have been advocating for the past decade was, I believe, the first step made towards bringing forward the machine to its true place as a factor of production. But I must confess that until this principle of the transference of skill was brought out so clearly by this report, I did not realize exactly why the machine tool was frequently so surprisingly ineffective under indifferent handling.

I will pass over the acceptance by the committee of the three regulative principles of management, viz: (*a*) the systematic use of experience, (*b*) the economical control of effort, and (*c*) the promotion of personal effectiveness, which were worked out by Mr. Alford and myself, except to say that the credit for the formulation of these principles belongs in a larger degree to Mr. Alford than to me, and I will conclude my remarks by calling attention to a phrase used in Par. 51 of the report, viz: "the habit stage."

All the mechanism of organization in the world is valueless beside the steadiness of production that comes from the establishment of good habit throughout a plant. I will go further, and say that the whole object and end of organization should be to create the right kind and degree of habit in everyone of the persons engaged in production, from the president down to the shop sweeper.

It is not enough for the workman to be so instructed that he forms good habit. Every living link in the chain of production requires equally to be so trained that his acquired habit is harmonious with all the rest. The report has mentioned this aspect of the question where it insists that the executives and not the workman are the persons most important to be reached. Few people understand that the principal work of an expert organizer is not the designing of elaborate blanks and cards, but the fostering, with tireless patience, of correctly adjusted habit in each member of the staff.

As the new ideals of management engineering appear to me, and this view seems confirmed by the committee's report, they may be summed up in three sentences:

Take nothing for granted.
See that every effort is adapted to its purpose.
Cultivate habit.

These sentences are, of course, merely practical derivatives from the three regulative principles referred to in the report. Each of them in turn implies other things which will readily suggest themselves. Thus, the possibility of cultivating correctly adjusted habit depends obviously upon proper mental and physical conditions for the living forces. It implies " lead " and not " drive."

It is an interesting question where the new spirit that we find abroad in industrial management has come from. To some extent, I think, it is part of a larger movement, the realization of a sense of social solidarity, of social responsibility of each for all, that is so marked a feature of the times. But it also arises, in part, from another cause. Scientific men tell us that the great difference between a savage race and a highly civilized one is that the former remains in a condition of natural innocence, and the latter has arrived at self-consciousness. This, I think, is the real state of affairs in regard to management engineering. We are passing from a stage at which there was a simple and unconscious following of tradition, into a stage of self-consciousness in which we are moved to subject our habits and our motives to severe self-scrutiny, and examine afresh every item of our daily practice. It is a very painful stage to have arrived at. Most of us are so content with our comfortable natural innocence that we do not like to part with it, but it is a process that once commenced, must continue.

The examination into new methods of remunerating labor, the adoption, with caution, of searching instruments of analysis, such as time study, the use of precise methods of accounting—these are not causes, but *consequences*, of this newly awakened self-consciousness. It is beginning to be recognized that production is an aggregate of infinitesimal separate acts, in each of which there are three main components. First, experience must be drawn on; secondly, the resulting effort must be intelligently adapted to the end in view; thirdly, this intelligent effort must become habitual. And to secure the successful performance of these acts, the living forces concerned must be maintained in the pink of condition, both mental and physical.

C. B. Thompson.[1] A fact not to be ignored is that labor, organized and unorganized, has taken its stand, at least temporarily, in opposition to the development of scientific management. While many of the objections raised have been so unreasonable as to be abandoned almost from the start, there are three criticisms made by working men which persist in spite of explanation: In the first place, they seem to cherish an innate resentment against time study—"putting the stop-watch on them," as they express it. It "makes them nervous," "makes them speed up unduly while under inspection," "is simply another means of slave driving," "is used unfairly," "is un-American." They say also that the method of minute planning in advance and of specific instructions as to details, is destructive of the initiative which has been the backbone of American industrial progress. Further, they assert that the enhanced product due to these methods is not fairly divided between the management and the men; that an increase of 400 per cent. in production, as in the classic case of Schmidt, the pigiron handler, has been accompanied by an increase of only 60 per cent. in wages.

It is neither wise nor expedient to pass by these criticisms without comment. That they are all unmerited may perhaps be shown: for instance, it has been demonstrated that time study, carried on by one who is trained in the subject (and whose training is ethical as well as intellectual), is not unfair, nor is it used as a new method of driving, nor is it in any sense un-American. Time study has been carried on for decades in psychological laboratories for purely scientific purposes and with instruments even more refined than the despised stop-watch, but no one suggests that this use is open to criticism. When it is once clearly understood that time study in an industrial establishment, made under the proper conditions and by the proper persons, is aimed at similar scientific results, and that these results are then to be applied to work, subject to the mutual consent of employer and men, based on a conviction of their reliability and essential justice, these objections will disappear. But on the other hand, there is no doubt that time study can be and has been abused, and the working man has a right to be "shown."

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[1] Instructor, Industrial Organization, Graduate School of Business Administration, Harvard University.

Similarly in regard to the alleged destruction of initiative. Here the facts are clear. The machinist does not consider his initiative restrained when he is asked to do his work in accordance with the drawings supplied him by the drafting department. Systematic routing and planning of work and the development of a science by which it shall be done are, as the committee points out, analogous, for the production department, with the working drawing. We all believe in liberty, but we recognize, or are capable of being shown, that true liberty is liberty under law; that the artist is not in the least trammelled in his genius because he has been taught the laws under which he must use his materials; nor is the citizen any the less free because he, in common with all others, must conduct himself in accordance with the law of the land.

The problem of just distribution of the increased product is not capable of easy solution and demonstration, and much yet remains to be done in this field. No one has yet solved the problem of justice in distribution, and it does seem somewhat hypercritical to allege against scientific management that it has not done what any other movement or individual thus far has not been able to do. Rather it should be given credit for having pointed out the industrial necessity of justice in distribution, and of having proposed steps in that direction. The solution of this problem is not to be looked for from engineers. When an engineer wanders into the field of economics, he is apt to make about the same diverting spectacle that the economist would who would undertake to expound the principles of machine design. Probably the wages question will be worked out in the future as it has been in the past by neither the engineer nor the economist, but by the daily struggle and adjustment known as the "higgling of the market." In this struggle the rights of the working men will have to be conserved and enforced by organization. Only by pooling their strength can they meet the superior strategic position of the employers.

The report of such a committee as this should not have overlooked the opportunity to begin or extend the campaign of education in these particulars. Something more than education is necessary, however. Labor unions are a potent and active force in present-day industry, and we should get their enthusiastic coöperation. They are the culmination of decades or centuries of development. In spite of their numerous mistakes and injustices they have, on the whole, justified their existence; and whether you agree that they have or not, they are a condition and not a theory that confronts us. It would seem to be the part of wisdom, therefore, not to take the tack of ignoring or combatting the doubts and questionings and opposition of the labor unions, but rather to persuade them of the advisability of acquainting themselves with the facts, of recognizing the inevitability of the march of labor-saving management, and to secure their active coöperation in its development. A proposal at this time to retain their positive help in the extension of scientific management may seem Utopian, but it is warranted by certain facts and precedents in the history of trade unions. They have already established their right to determine the lighting, heating and ventilating facilities of establishments in which their members work. There are cases on record in which they have required owners of old plants to scrap their obsolete machinery and install new and modern devices, in order that the owners themselves may make sufficient profit to pay adequate wages to their employees. *It is but one step, and a short one, in the extension of this principle to say to the owner that he must modernize his establishment in every detail, not because the working man is interested in the owner's personal profits, but because only such an establishment can pay the working man the wages which his standard of living demands.*

The objections of the working men are naturally grounded in their personal experience and interest. The criticisms of the "friends of labor," however, are in most cases disinterested;

though it must be said that in too many cases they are based upon a faint acquaintance with the facts. So far as they are disinterested, they must be recognized and met. It is sheer folly to adopt the attitude of the "hard-headed business man" and display a lofty contempt for the increasing interest in the welfare of the working men, which has been developing into a powerful force during the last century. "Hard-headed" is too often a mere euphemism for hard-hearted. Intelligent humanitarianism is not only legitimate but is one evidence of upward progress, and is neither to be ignored nor treated with contempt.

But business men have a right to ask the humanitarians that they be intelligent and informed. It is the business of business men to supply the information needed from the data which are usually at their exclusive disposal. When, for instance, it is alleged that scientific management is "dehumanizing," the charge should be met with the actual histories of men who have worked under this system. Many plants where it has been developed can show, on the part of their employees, an increase of leisure, of interest in their work, of knowledge and improvement in general character, and an enhancement of all-round welfare. Mr. Taylor, and especially Mr. Gantt, have not ignored this side of the subject; but, in proportion to the mass of data in their hands, their contributions have not been full enough. This committee must have had an opportunity to look into this side of the case; and it is to be regretted that they have not improved it more fully.

In a remarkable book, Fatigue and Efficiency, by Josephine Goldmark, published by the Russell Sage Foundation, a chapter is devoted to The New Science of Management: Its Relation to Human Energies. In this chapter are pointed out the advantages of the new methods from the point of view of the working man. After enumerating the perversions to which scientific management may possibly be put, the author says: "If the unscrupulous use of scientific management were all that could be charged against it, the system could defend itself easily enough. . . . More serious is the contention that the efficiency engineers themselves have failed to gauge fairly the tax of increased productivity upon the workers. . . . What we need as regards both men and women (and the only answer which will allay the suspicions aroused by scientific management) is more knowledge as to the ultimate physical adjustment of the workers to the heightened intensity of their tasks." And lest this seem to have too philanthropic a sound, I hasten to add the word of a prominent manufacturer, William C. Redfield, of Brooklyn. He says: " Once for all, let it be said that no management is scientific or permanently profitable which either promotes or permits human overstrain, or which taxes the future of women and children." This reflects, I think accurately, the judgment of many thinking people. The problem of the health of employees is one which demands and must have adequate consideration. No one who knows scientific management at first hand can deny that it has been given such consideration by those who are entitled to class themselves as scientific managers. Miss Edith Wyatt's investigation of the subject with reference to women workers, the results of which are described in Chap. 7 of the book by Clark and Wyatt, " Making Both Ends Meet," is conclusive on this score (and incidentally is somewhat misrepresented in Miss Goldmark's discussion). Numerous instances of the effect of this work on the health of employees might have been collected by the committee and should be given.

I know of a case of a girl who asked to be put on a task 50 per cent greater than what she had theretofore performed. At the time she appeared to be in a sickly condition. The factory nurse was consulted as to the advisability of allowing her to undertake the task and gave her consent on the condition that the girl be allowed to go back to her ordinary work if at the end of a fair period it was evident that the task was too severe for her. After the expiration of four weeks the nurse reported (and it was already evident to the manager) that the girl was not only doing the task easily but had greatly improved in health. This in the nurse's opinion, was due partly to the improved condition under which the girl worked, to the better method she had been taught, to the higher wages she received, and to her increased contentment. This same girl shortly afterward asked for an increase of 33 1/3 per cent more in her task, but this was refused.

In this report the committee emphasize the " transference of skill " as the basic feature of the new labor-saving management. Unfortunately, however, it appears that this term is used with two meanings. Throughout most of the report it seems to mean the accumulation of skill by the planning department and its transference from this department by actual instruction to the workmen just as machinery is said to be the transference of skill, according to the report, from the designer and draftsman to the machine. The idea intended to be conveyed is undoubtedly right, but the illustration chosen is unfortunate.

Transference of skill, when considered with reference to the industrial revolution and the introduction of machinery, might easily be interpreted to mean the transference of skill from the workman to the machine. What actually happened was that the machine brought to the aid of the workmen some of the vast forces of nature; and in addition it superseded the skill of the hand worker. That this was a distinct loss to the hand worker who was unable to adjust himself to the new conditions is incontestable in the face of economic history; and the sad record of the change is a solemn warning to present day managers to take every step possible to make the adjustment to new methods of management as easy and gradual as possible. The machine developed a new kind of skill on the part of the operator; but now it is a minute skill easily acquired and subject to sudden loss with the change in the design of the machine.

The old-fashioned, all-round workman has disappeared or is rapidly disappearing; and though his replacement by the modern, keen-eyed, high-strung, quick-moving specialist is not to be altogether deplored, it has had certain serious consequences. It has made the present day operator narrower in his knowledge of industry and his skill less adaptable and elastic. It has also rendered obsolete the old methods of apprenticeship, and the present chaotic condition of this subject presents a striking illustration of the failure of managerial thought to bring about the necessary readjustments.

It seems to me important that the committee's meaning on this subject be made unmistakable. No one can reasonably and seriously object to the transference of skill to the workers by the "systematic development of a science" and "systematic training."

H. M. WILCOX[1] wrote that he felt that through the unfortunate adoption of the term labor-saving management, the committee have allowed themselves to lose the perspective of the subject of scientific management as a whole. The definition of the word science is "knowledge duly arranged and systematized, and this so-called new element in industry is chiefly the arranging, systematizing and recording of principles evolved by the art of management, so that the term scientific management is the most logical to use. The term labor-saving appears to have detracted from other phases of scientific management.

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[1] Miller, Franklin & Co., 17 Battery Pl., New York.

In a conversation with Mr. Frank O. Wells, his attention had been called to the fact that practically every industrial plant of any size had a purchasing agency for materials, but how many had a purchasing agent for labor?

H. L. Gantt. The difficulty of making a satisfactory report on the present state of the art of industrial management can be thoroughly understood only by those engaged in the installation of the new methods. The Committee have caught fully the present spirit of the movement now in progress, and Par. 45 to 58 of their report seem to me to be an excellent resumé of the subject.

In Par. 21, however, we find the following statement: "Another tendency, less pronounced in character, has as its object the improvement of the personal relations between employe and employe, and between employe and employer."

This tendency which is described as being less pronounced, I believe to be the most important part of the whole subject, for until proper relations are established between employer and employe, no system of management or training can be permanently successful.

When the methods described by the committee were first presented, many people thought that they were simply new schemes for exploiting the employe for the benefit of the employer. However false this impression may have been, it was undoubtedly widespread, and formed a serious obstacle to their introduction. How deeply rooted this idea was in the public mind can best be appreciated by reading the discussions of my paper on The Training of Workmen.[1]

Since that time the prominent writers on the subject of management have emphasized the necessity of establishing proper relations between employer and employe, realizing that no scheme that does not recognize this as an integral part can be permanent. Unfortunately this has not yet been acknowledged by everybody to be a fact. Many people value these methods only as new ways of controlling workmen for their exclusive benefit, and become interested in them only in times of trouble. Financiers seem particularly prone to take this view.

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[1] Trans. Am. Soc. M. E., vol. 30, p. 1053.

To illustrate this point, about a year ago I was consulted by a large corporation, which, however, took no further steps. Recently the same corporation was much interested in the subject of management, and I found that its employes were on the verge of a strike. The strike, however, did not come off, and the interest of the management apparently died out when the danger disappeared.

While the idea of exploiting workmen for someone's benefit is obnoxious to most people engaged directly in industrial pursuits, this is not the case with those farther removed from the workmen.

If I am to judge from the letters I received after the hearing before the Interstate Commerce Commission in Washington in November, 1910, many people thought they saw in this movement a chance to get something for nothing. So strongly was I impressed with the extent of this attitude that I felt impelled to condemn it most strongly in my address at Dartmouth a year ago. When I was leaving the hall after that address, a benevolent looking old gentleman came up and said: "Of course you will modify that before it is published?" and I did, but not just as he meant.

I regret that the committee did not include in their bibliography of this subject, books and papers published elsewhere than in the annals of the Society, for some of the very best work on this subject has been done in the last three years, during which time the Society has nothing to show. I wish to call especial attention to the work of Major Hine on Modern Organization and to that of Hon. William C. Redfield on The New Industrial Day. Both of those books, just published, will well repay careful study, as they are in accord with the democratic as opposed to the autocratic spirit in industry.

With regard to the minority report, a careful reading seems to indicate that the writer of it is practically in accord with the majority, except that he wishes to take a shot at the statement made before the Interstate Commerce Commission that the railroads were losing one million dollars per day. I must confess that when this statement was made it seemed to me rather extravagant, but a careful study of conditions for the past two years has convinced me that the statement was conservative rather than otherwise if all preventable losses are included.

The writer of the minority report is connected with what I believe to be one of the most progressive and best managed railroads on this continent. I did a little work for him a few years ago, first, having in conjunction with Messrs. Dodge and Day of Philadelphia, made a report on the conditions in his shops. Our report expressed the opinion that his method of operating these shops was at least as good as that of the best railroad shops we knew anything about, and we visited several representative shops in this connection.

The real inefficiencies with which I came in contact on this road, however, were not in the shops. They lay in antique timekeeping, record-keeping, cost-keeping, and purchasing systems, which were run, not for the benefit of the maintenance and operating departments, but apparently to hamper these departments to the greatest possible extent. Inasmuch as most roads handle these functions in substantially the same manner, I believe that the inefficiencies of railroad operation, due to the lack of appreciation by the financial end of the needs of the operating end, are far greater than those over which the operating end has absolute control.

Railroads are built nominally to earn money for their stockholders by the sale of transportation. If this were the only way they could be used to get money, all activities connected with a railroad would be so run as to assist in the economical production of transportation, just as all the activities of a well run foundry are harmonized for the production of castings at low cost.

As a matter of fact, the financial end, including the purchasing, store-keeping, time, cost, and record keeping, does not as a rule consider economical operation as any of its affair, but puts this responsibility entirely up to the operating force. The best railroad managers of today, however, see that real economical operation cannot be had unless all functions contribute to that end, just as they do in the best managed factories.

Unfortunately this is a view that the average financier finds difficulty in accepting, especially if he has always been a financier. A proper comprehension of this subject, however, is the best way to head off the growing sentiment for the government ownership of railroads.

Turning again to Par. 21, concerning the relations between employer and employe, any scheme for the training of workmen, or promoting the transference of skill, if that term is preferred, to be ultimately successful must carry with it a guarantee on the part of the management that the employe shall receive his share of the product of his increased efficiency or skill. Increasing the efficiency of a workman thus differs radically from increasing that of a machine, which claims no share of the results.

If, however, the attempt to increase the efficiency of the workman is made in such a manner as to lead both employer and employe to feel that he is getting what he should from their mutual efforts, the promotion of efficiency is sure to follow, and we have a working basis on which to attempt the solution of some of our industrial problems. As long, however, as such prominent men as Mr. Parry and Mr. Kirby of the National Association of Manufacturers continue to use such language as they have in the past in speaking of workmen, just so long will the workmen continue to use brute force in dealing with employers, and a satisfactory solution of the labor problem be delayed.

The implication in the report of the committee that the development of methods and the training of workmen are functions of the management has to my mind not been sufficiently emphasized. The piece-work system as usually operated, and most of the premium and bonus systems in general use do not recognize training as a function of management, and may be classed as individual effort systems. They have undoubtedly accomplished some results in the past, but we have now reached the stage in our complicated industries where more than individual effort is required. Individual effort may be so hampered by environment as to make progress impossible, and to cause the workman to become so discouraged as to give up whatever effort he may be making. On the other hand, if the management determines that a certain degree of efficiency is attainable, accepts the responsibility of training workmen up to the point necessary to obtain that efficiency, and provides means for obtaining it, we have an entirely different condition.

This view of the subject is so opposed to that held by most managers, superintendents and foremen that it is with great difficulty that we can get them to accept it, and the time needed to bring them around to this viewpoint is far greater than most realize. There are many reasons for this, and the fact that a man does not instantly accept a new proposition, which is to his mind revolutionary, should not for one minute be held up against him, for a strong man who has been successful in following one line of action, justly regards an entirely different line as being inferior to one which has brought him his success.

Fig. 1 represents the work of women winding yarn in a cotton mill after the system had been in effect one month, at which time three operatives were regularly earning a bonus. At the start, one of the best workers was offered the opportunity to perform the task and to earn bonus, but she felt the task was too severe and did not wish to try. A week later, however, she did begin the work and made her bonus right along. Some of the people in this room were young girls who apparently had but little interest in the work and made practically no effort to earn their bonus. The older and more staid ones, however, took hold promptly and the younger ones gradually dropped out. The newcomers at first spent three or four weeks before they actually earned the bonus. As, however, those who were not interested in earning the bonus gradually disappeared, the habit or fashion in that room came to be—attend to your job and earn the bonus. The newcomers then in many cases earned their bonus from the very first day. This chart is dated March 1909. Fig 2 shows a chart of this room as it exists today and is reproduced by permission of the treasurer of the mill.

Some months ago the Industrial Workers of the World made an attempt to cause a strike in all of the mills in the town where this mill is situated, and actually succeeded in shutting down some of the mills for several weeks. In this mill, on which a strong attack was made, only 60 out of 600 employes were drawn out, and the management had no difficulty whatever in filling all their places in a few days.

Fig. 3 represents the work of girls in a worsted mill. The best workers were put on bonus work first. Their improvement is noticeable. It was nearly three months before all were put on this work. The poorer ones failed at first, but on the last day shown on the chart all of the poorer workers earned bonus. During the period from April 15 to July 10, one-hundred and sixty-one girls had been put on bonus work, and 21 out of this number had for one reason or other left the employ of the company. The reasons were as follows: four left on account of poor health or were dissatisfied; one married; one entered a convent; one went

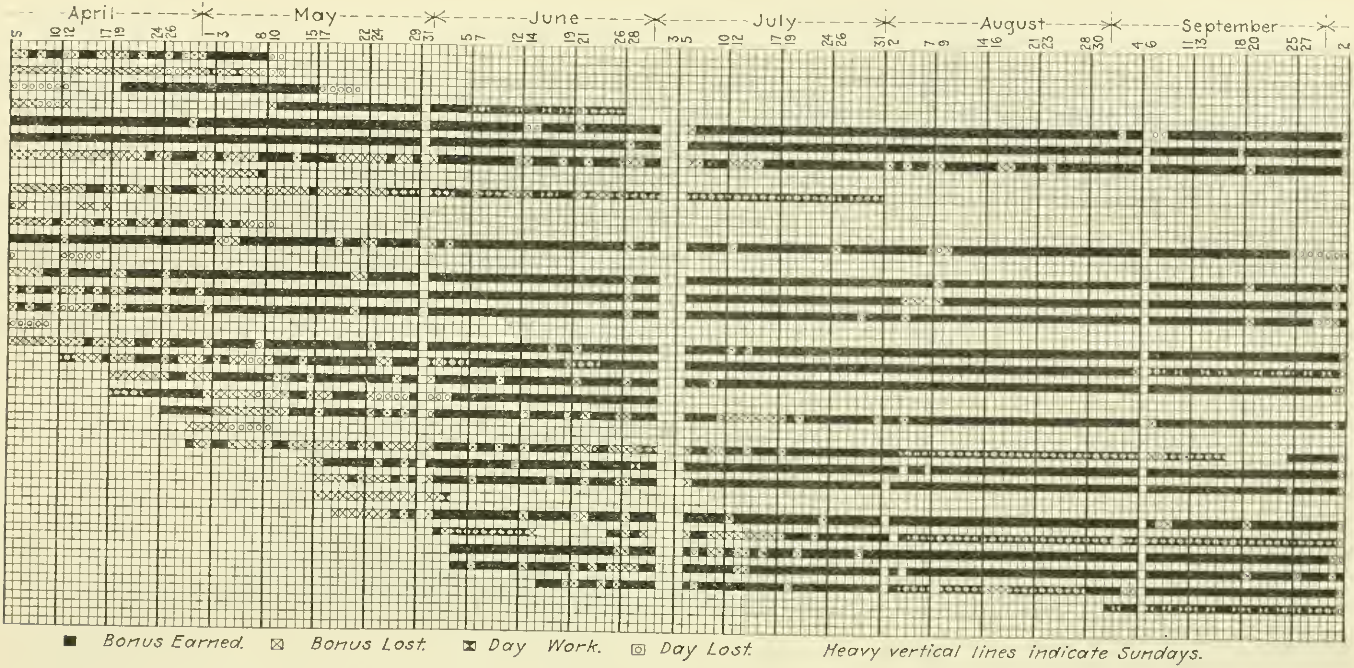


FIG. 1 CHART SHOWING RESULTS OF BONUS SYSTEM: WOMEN WINDING YARN IN COTTON MILL, 1909

Each line is the record for one worker. Note how much more quickly new workers put on in June began to earn bonus than did those in April or May to work at the mountains for the summer; five left town and nine were discharged.

One of the obstacles nearly always encountered is the opposition of certain people in authority who, having once expressed their disapproval of these methods, feel it their duty to oppose their introduction to as great an extent as possible. Their original arguments having failed, the argument that we were overworking the girls was advanced and they insisted on being allowed to put on piecework some of this work which was in another building, and which had not yet been put on the task and bonus system. Accordingly, on June 19 their piecework was started. On July 11, the date of the report, 19 out of a total of 53 girls in this building had left. In other words, almost one-third of the girls who were put on piecework according to the request of the man who had their interests most at heart, left in three weeks. In the case of our bonus workers, approximately one-eighth of the girls left in 15 weeks.

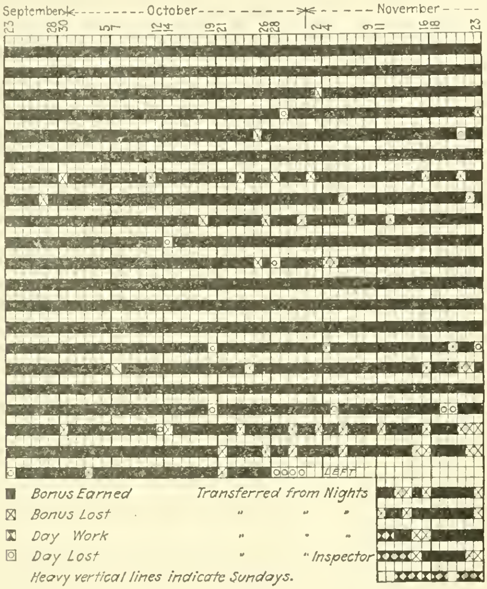


Fig. 2 Conditions Existing in 1913 in the Department represented in Fig. 1

In 1904 I put this system into a shop making packing boxes. A few weeks ago I had word that it was running substantially

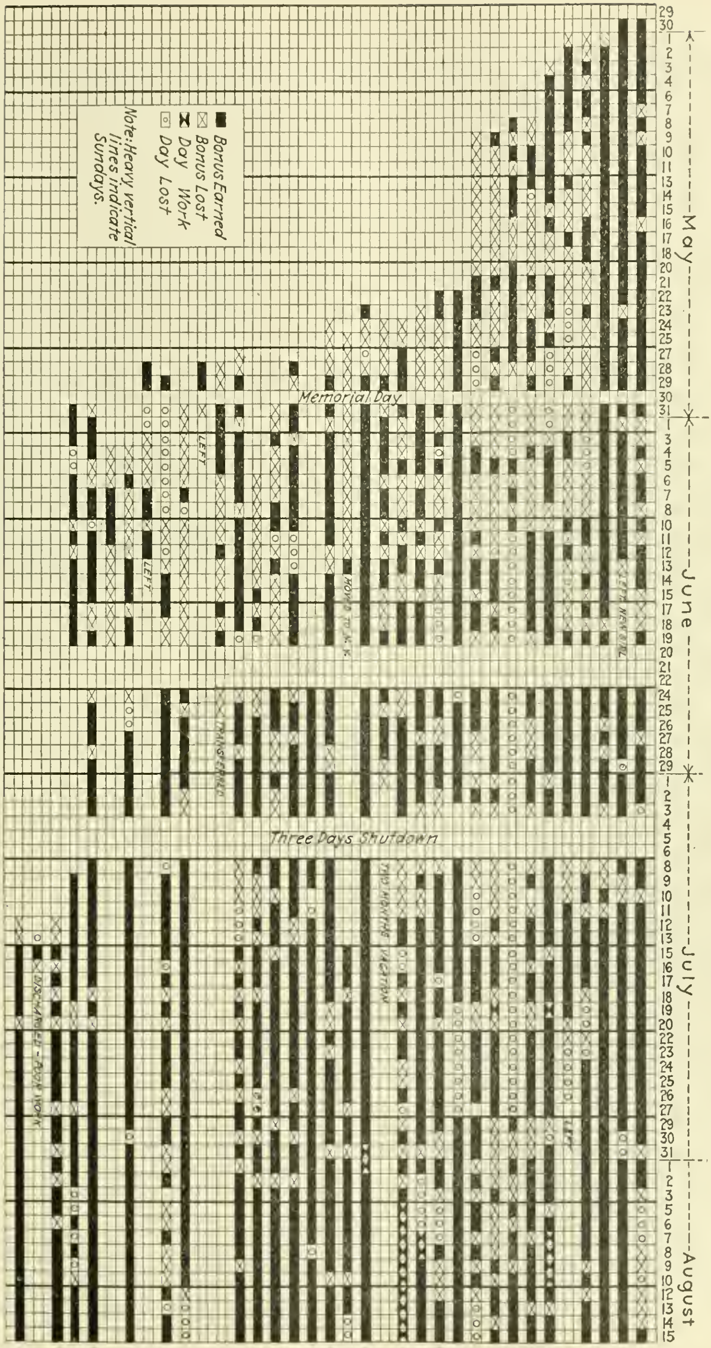


Fig. 3 Record of Work in Worsted Mill

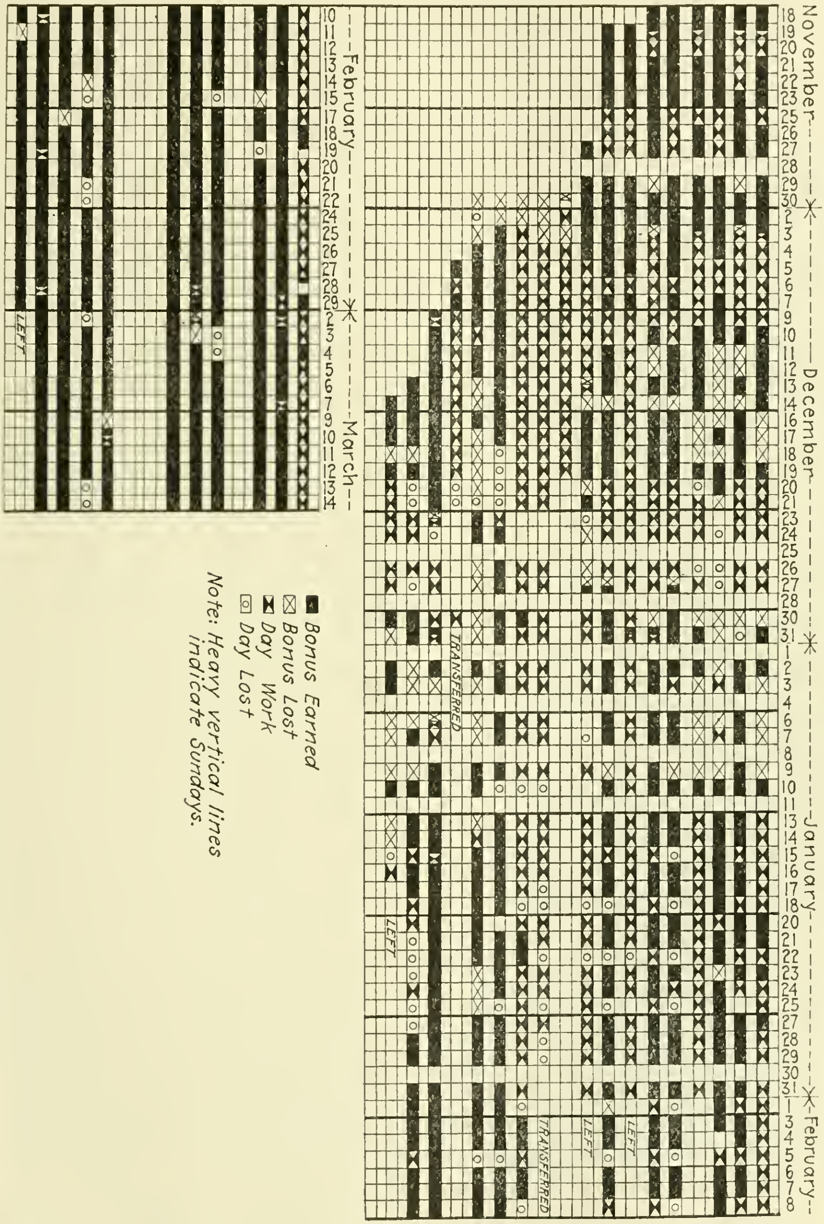
Each line represents one worker. This is a sample chart for one room. There were several other rooms as it was started and that nearly all of the original bonus workers were still there.

Fig. 4 represents the making of sheets and pillow cases and the work of starting the task and bonus was done by a man who had been connected with me, but who was doing this on his own responsibility. I was not personally in touch with this work when it was done. The factory was shut down on a number of days, November 28 (evidently Thanksgiving day) and then on Christmas and all Wednesdays and Saturdays for the next two weeks. The work started off very well, but the rush to get people on bonus on November 30 evidently upset things, for a number of workers are back on day work. This was probably due to the inability of the task setter to set tasks on new work fast enough. Just before Christmas week the same condition obtained, and after Christmas there was not enough work to keep the factory running full. However, by the middle of January those who had bonus work were beginning to earn their bonus pretty regularly, and by February 10 the number of workers was just about large enough so that each could be supplied with a full amount of work. From that time on the work went smoothly.

It is evident from this chart that the management has its part to play in supplying work and teaching workers, and that the trouble was not with the workers but with lack of proper balance in the managing department. The fault, however, is a natural one, for when the man responsible for the output finds the advantage he can obtain by the task and bonus system he almost invariably insists on putting as many people on bonus as possible, with the result that he finds he cannot supply all the workers properly and that numbers of them have to be put back on day work.

You will ask why the task setter does not explain this to the superintendent and make it clear that that is the wrong way to do. I can only say that no amount of explanation on my part, or that of my representatives, seems to have much effect and we have about come to the conclusion that the best way to do is to let them make their mistakes and find out, then the question is settled once and for all time.

Fig 5 is a particularly interesting chart inasmuch as it is the most recent—the development is still going on. It is reproduced by the courtesy of the manager. In this the work went



Note: Heavy vertical lines indicate Sundays.

FIG. 4 RECORD OF WORK IN MILL MAKING SHEETS AND PILLOW CASES

very well until we began to push it too fast. When the desire to get an increased output overcame the conservatism with which it is necessary to establish a new method, those workers who were last put on influenced the others not to perform the task, and on one day nobody made bonus. One girl, however, felt that she needed the money and continued on with the work. The others showed their hostility toward her in a number of ways, but she still persisted. After they had ceased to try to do the work for three or four days, several of the girls sent in their notice that they were going to quit. They were evidently trying to raise an issue, but inasmuch as the management ignored it and went about its business of getting conditions so perfect that the workers could have no cause whatever for not trying to earn their bonus, they were unable to get the issue accepted. At the end of eight days some of the girls became willing to try again, and from that time on the number increased. For some time past the applications from other girls to work on task and bonus has been so great that we have been unable to provide proper conditions and to set tasks for them fast enough.

The question naturally arises with respect to the charts as to the ratio between the amount which is being accomplished now and what was accomplished previous to starting in with this work. In order to make these comparisons clear we devised what is called a Percentage Chart. On this the average production previous to the installation of our methods is called 100 per cent. Our new production may be two, three or four times that amount. The wages paid before the work was started are also rated at 100 per cent. The new wages would be an increase over the old standard, usually of from 30 to 50 per cent and the wage cost measured in the same manner would be distinctly below the previous wage cost.

Fig. 6 shows these ratios with regard to work done several years ago in a bleachery in Rhode Island. Each of the vertical lines represents a different kind of work. The horizontal black line marked 100 per cent represents the amount of work which was done on each of these operations previous to our investigations. The upper lines represent the amount of work now being done, compared with what was previously done. The heavy black line marked 100 per cent also represents the previous wages paid, and the dotted lines above it represent wages now paid. The 100 per cent line also represents the previous wage cost. The

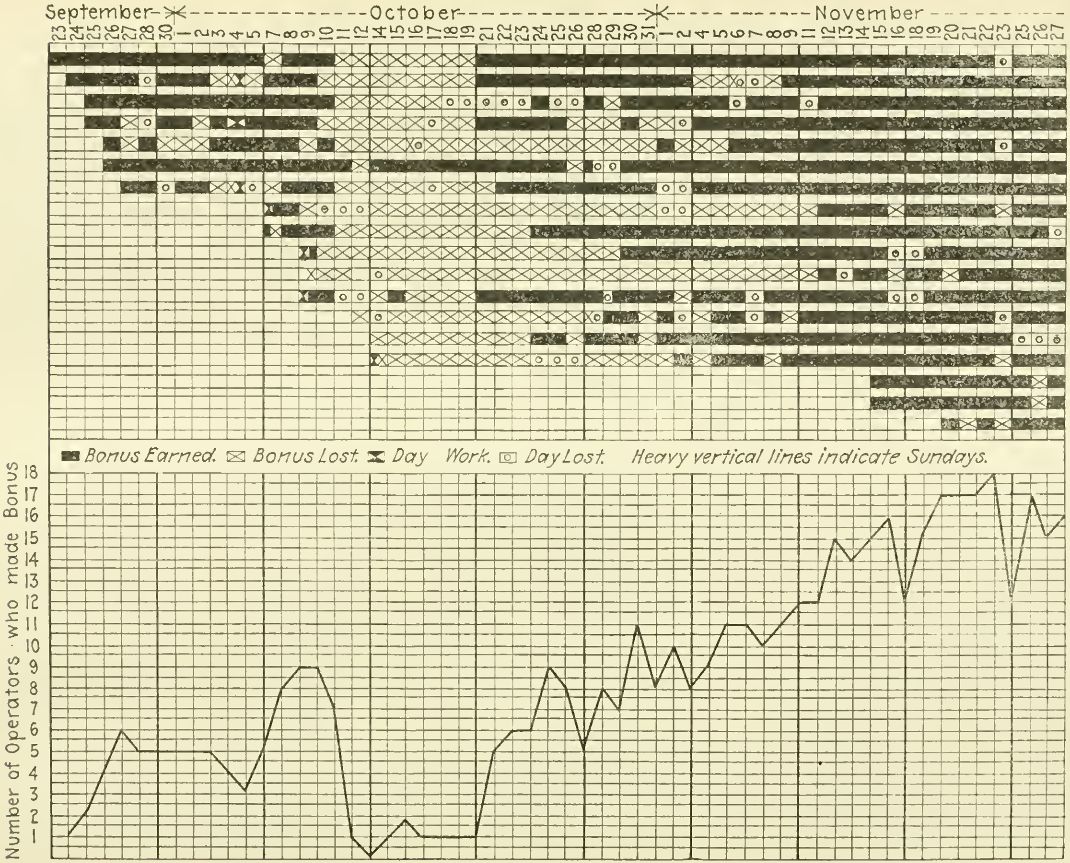


Fig. 5 Chart illustrating Bonus Work in Factory where the Effort was made to increase the Output too Rapidly

dotted line below represents the present wage cost. The increase in product is around 200 per cent and the decrease in wage cost is approximately 40 per cent, while the increase in wages is also 40 per cent. It should be borne in mind that *this increase in product is not due solely to the work of the operative, but also to more careful study and coöperation on the part of the management as well.*

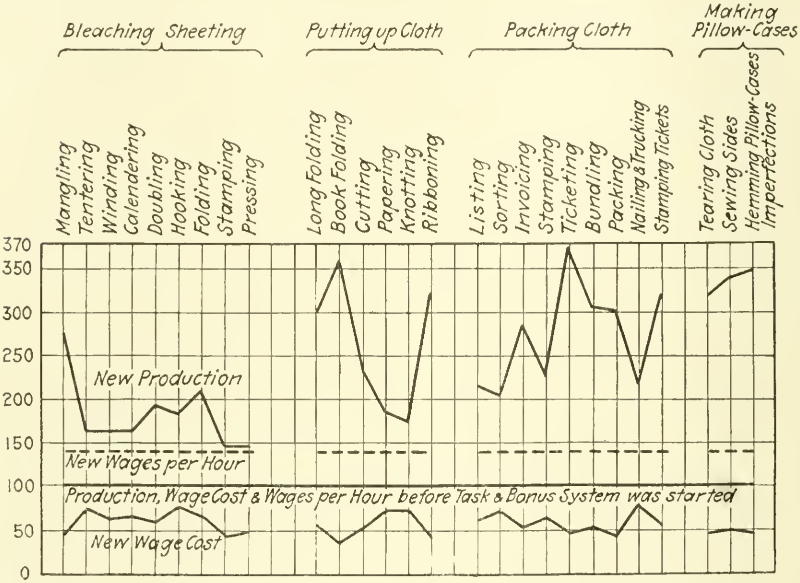


FIG. 6 ACTUAL RESULTS UNDER THE TASK AND BONUS SYSTEM AFTER MORE THAN TWO YEARS' OPERATION

Each Vertical Line Represents a Different Operation

Fig. 7 shows similar results for work on small automatic screw machines. In this case the light line represents the task; the upper heavy line the amount of work done; the upper dashed line the wages now being received; the lower dashed line the new wage cost. In this particular case the shop was well run before we undertook to study the work, and the workmen were getting good wages. The increase in production is not quite so high as in Fig. 8 which shows similar results for large automatic machines. Fig. 9 represents the same change for miscellaneous machine work in a plant manufacturing a small article in quantities.

Comparing all four of these charts it will be noted that there

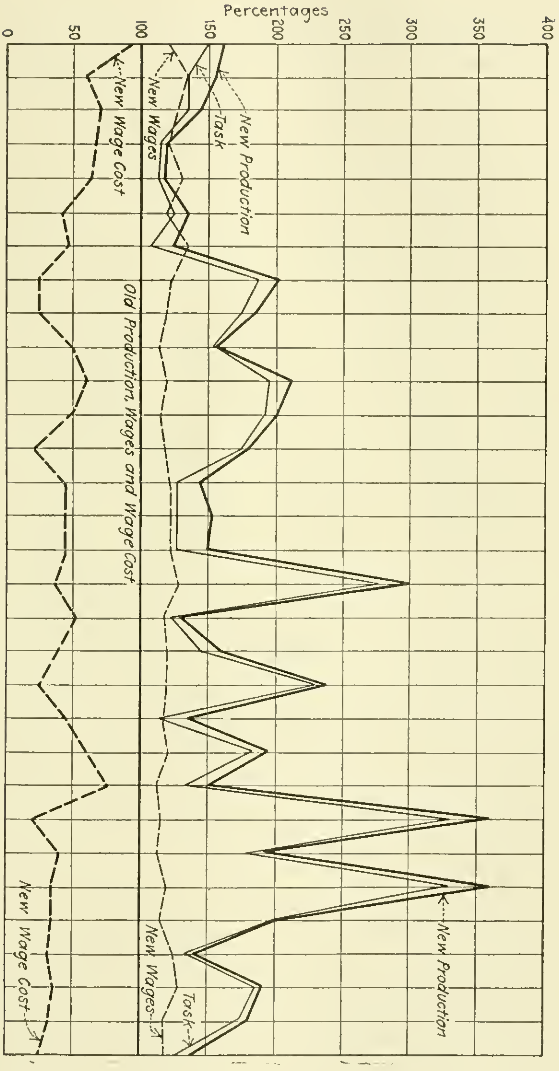


FIG. 7 WAGES AND PRODUCTION DIAGRAM ON AUTOMATIC SCREW MACHINE WORK
Each Vertical Line Represents a Different Operation

is a very striking similarity whether doing handwork in a bleachery or automatic lathe work in a machine shop. If the management assumes its share of responsibility in preparing the work, in seeing that the machines are in proper condition, and in training the workmen, we can get from two to three times as much work done as is usually done, pay 20 to 50 per cent increase in wages and still save about 40 per cent in wage cost.

This increase in output brings down the overhead expense on every unit of product so that the decrease in wage cost is not the only important item. It is not even the most important. Unless the overhead expense is markedly increased when the product is increased this expense per unit of product comes down substantially in inverse ratio to the amount that the product goes up. The reduction in cost from this source is usually markedly greater in dollars and cents than the reduction in wage cost. This side of the cost question has been given too

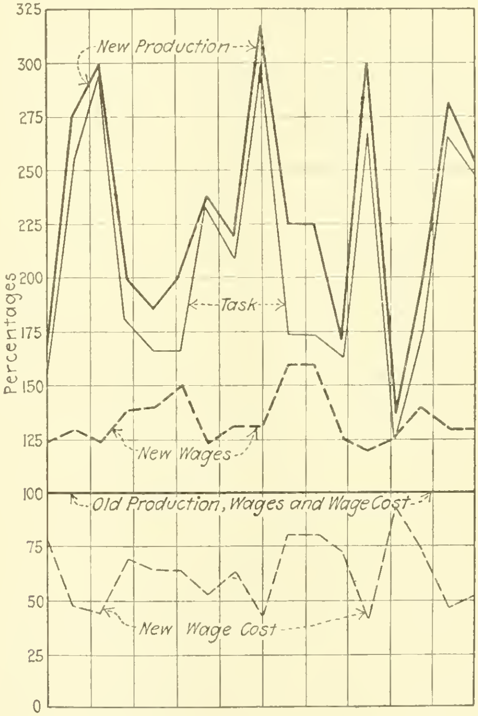


FIG. 8 WAGES AND PRODUCTION DIAGRAM ON LARGE AUTOMATIC WORK

Each Vertical Line Represents a Different Operation little consideration. Andrew Carnegie was among the first men in this country to recognize the great value of getting a larger product from his plants, and this, perhaps more than any other fact, gave him the mastery of the steel business. Many times we can afford to pay even a higher wage per piece if thereby we can reduce this overhead expense. In general, however, a thorough study of the work enables us to reduce both wage cost and overhead expense per unit of product at the same time substantially increasing the earnings of the workman.

In Fig. 9 will be noted a discrepancy in certain cases between the task set and the amount of work performed, showing that the workman did a great deal more than expected. It is asked, naturally, how we could overcome this difficulty, for many would feel at once that a serious mistake had been made and that the tasks should be increased or the rates reduced.

In reply, these tasks were set by a task-setter who had not had sufficient experience. We, however, do not consider that because he has made an error that it is necessary for us to change the rates. As a matter of fact, we rather prefer that there should be a few easy tasks so that the workmen may have a practical demonstration of the fact that we are not going to cut rates and that they need have no fear whatever if they do all the work they can and earn all the money possible.

Another comment may be that these shops must certainly have been run very badly before. While some of them perhaps were not in the class of well run shops, others were, and high up in the class. Before the introduction of these methods the results achieved were due to the effort the workman put into his work, with but practically little direct assistance from those over him. After the methods were installed he was taught the best way of doing the work that we could devise, offered a substantial reward for accomplishing the desired results in the manner in which he had been taught, and the conditions under which he was working were so modified that these results could be accomplished if the worker had been properly trained. In other words, these results are not accomplished by the workman alone and unaided. He had the thorough coöperation of a strong management.

Another criticism may be that no account is taken of the indirect labor, such as transportation, clerical work, etc. In reply, we find as a rule that there has been even less attention given to the proper study and planning of indirect labor than to direct labor, and that the chance for improvement in that line is quite as great as, if not greater than, in the line of direct labor.

My object in presenting so many charts which illustrate the same thing, is to show to as great an extent as possible that the principles laid down in this discussion are of wide application; and that in all cases substantial results may be expected if these principles are properly carried out.

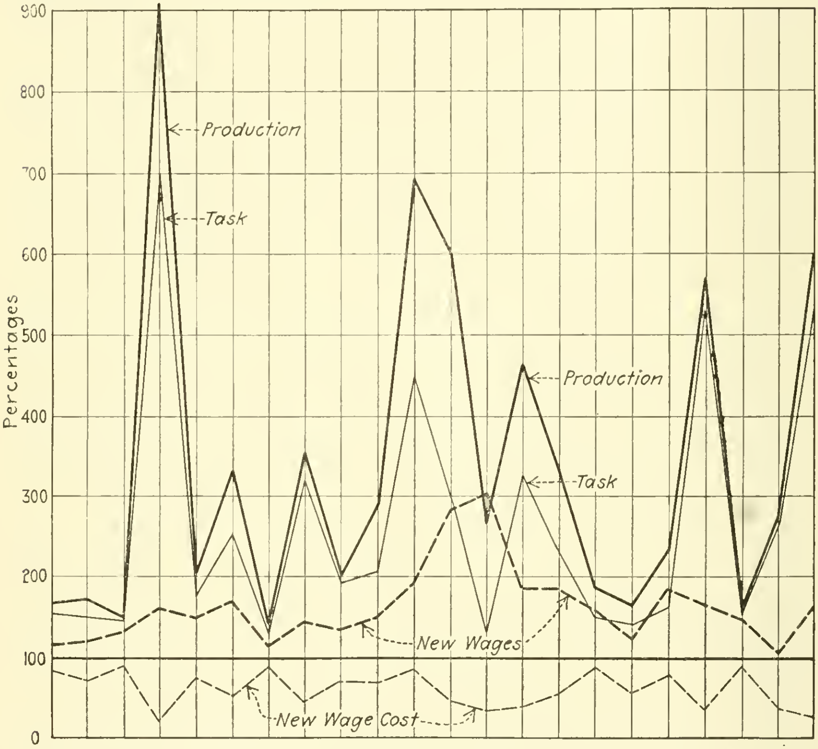


Fig. 9 Wages and Production Diagram on Small Miscellaneous Machine Shop Work

Each Vertical Line Represents a Different Operation

The essential point in carrying out these ideas properly is that they should be *understood, and thoroughly appreciated by the people who undertake their application.* The results shown cannot be accomplished unless we have harmonious coöperation between employer and employe, which is impossible under the form of management which assumes that the responsibility of the manager has ended when he has issued his instructions to the shop.

To my mind, the training of workmen to fill all the different positions in a factory is one of the important functions of the management, and we all know that training is slow and expensive, but it is the only method which holds out any hope of producing even a partial solution of our present industrial problems. This training cannot be accomplished by following blindly a lot of rules. The men responsible for the training must understand clearly the reasons for every step before they can teach employes to follow them intelligently.

John G. Aldrich. I believe that the report of this Committee is right. Scientific or labor saving management is scientific measurement and everyone will agree that this is desirable. The importance has been pointed out in this report of the study of production by scientific methods and of setting up standards. It is impossible to make up standards without first making a careful study of the correct motions and of the times required to make them.

The New England Butt Company, of which I am manager, is doing some work along this line to which I would like to call attention. This company builds largely machinery for making braids, such as trimmings for ladies' dresses, shoe strings, coverings for insulated wires, etc. The machines are made up mostly of small light castings which are machined but little, but which must be well made so that the parts will fit together without filing or other hand work.

Within the last few years with the help of various experts we have continually made improvements in our manufacturing departments. Time study was made of different operations and of different methods and proper times were set on those methods upon which to base the various systems of payments for work performed. We are now using a method of time and motion study which has not been used before, and which not only gives more accurate results than have been heretofore possible, but also enables us to discover methods that are much more economical.

This method consists of taking motion pictures of the various operations with a special moving picture camera, and photo-

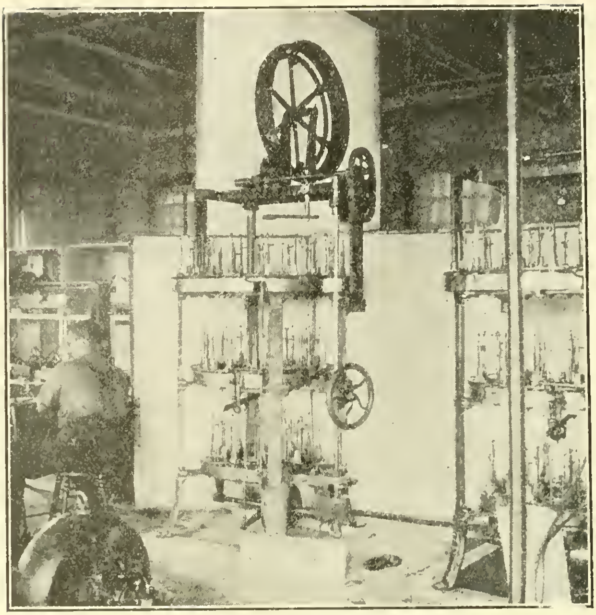


FIG. 10 DOUBLE DECK BRAIDING MACHINE

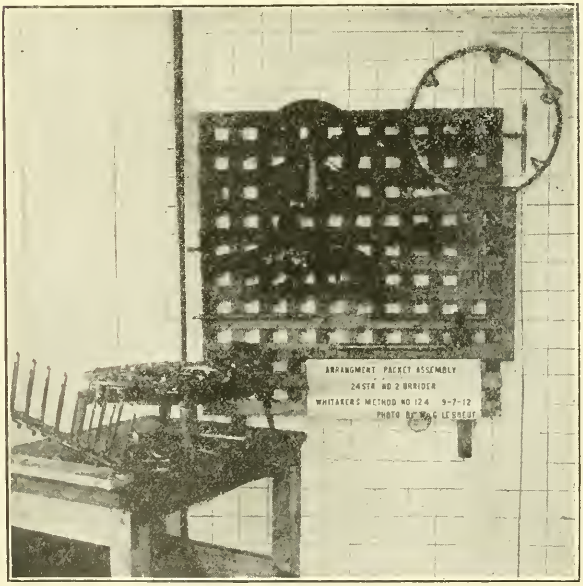


FIG. 11 TYPICAL PORTABLE ASSEMBLY BENCH AGAINST PACKET WITH THE PARTS ARRANGED FOR ASSEMBLING A BRAIDING MACHINE

graphing in each picture a clock of special design showing minute divisions of time. The hand of this clock revolves once in six seconds so that the divisions represent thousandths of a minute and are easily read to half thousandths. The continuous motion picture film furnishes permanent record of times and motions. To develop improved methods this film is afterwards studied with a magnifying glass and it is not necessary to project the pictures on a screen.

Before taking these pictures considerable study was given toward eliminating waste motions and otherwise improving the conditions under which the work was done. In assembling machines, instead of picking up the pieces to be assembled from various boxes, packets were arranged with the parts placed in convenient positions, and also placed in the proper sequence, so that no mental process was required of the workman to determine or select the parts to come next.

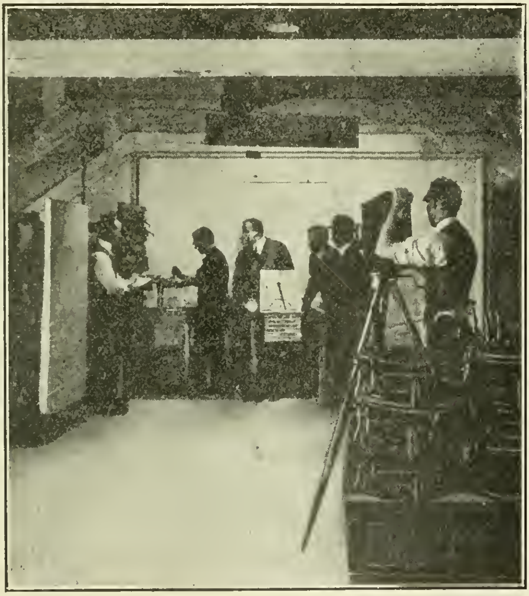
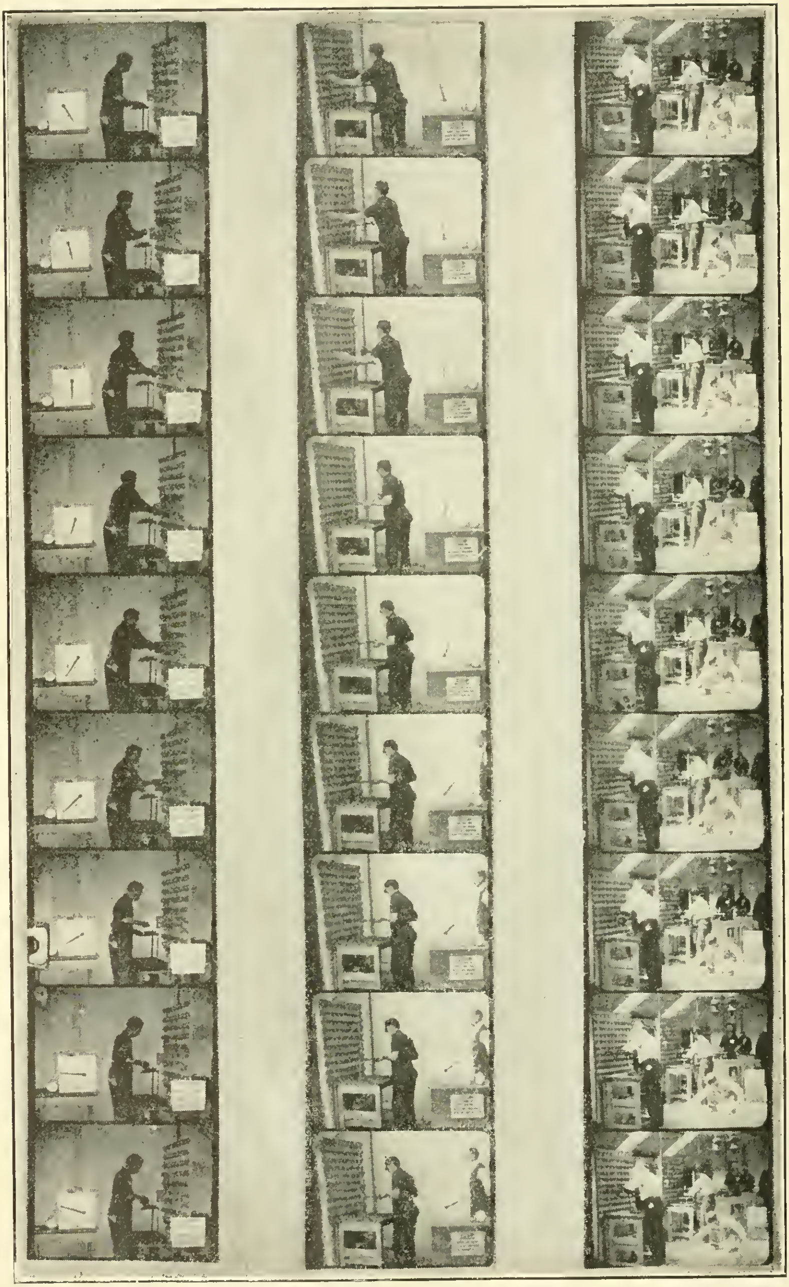


FIG. 12 MOTION PICTURE MACHINE RECORDING THE MOTIONS OF A WORKMAN

Since using this method, which we have designated micromotion study, previous times have been reduced over two-thirds. Its records have suggested to us methods that now permit in one



IGS. 13, 14, 15 Sections of Motion Picture Films of Workmen Assembling a Braiding Machine case doing work in $8\frac{1}{2}$ minutes that before using micro-motion study took $37\frac{1}{2}$ minutes.

Par. 6 of the report calls attention to a most important principle, " the transference of skill." Micro-motion study furnishes a means for the transference of skill from man to machine. More important than this it furnishes a means for the transference of experience from a man who has had it to one who has never had it. We have used micro-motion study for determining the correct times of the best motions in many different kinds of work. It is the least expensive as well as the only accurate method of recording motion and time study data. A few illustrations will give a clear idea of this process:

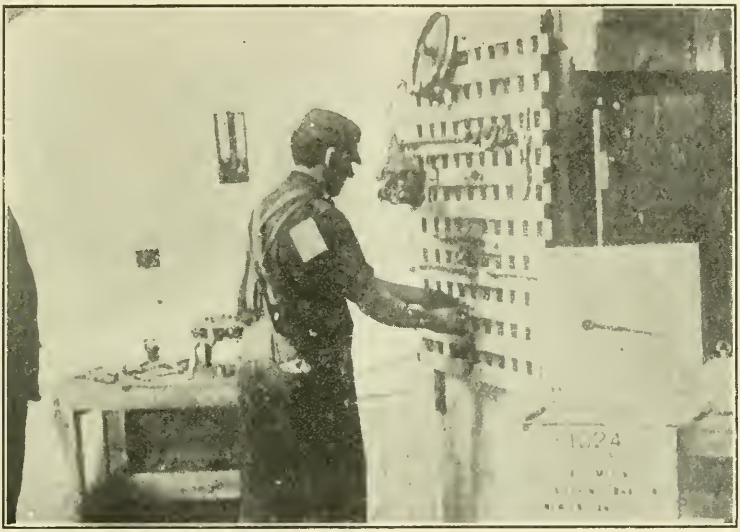


FIG. 16 ENLARGEMENT OF ONE PICTURE OF A MOTION PICTURE FILM

Fig. 10 shows one of the styles of braiding machines which we build and to which we have applied this method of time and motion study.

Fig. 11 shows a typical portable assembly bench against a packet with the parts arranged for assembling a braiding machine with the fewest and shortest motions.

Fig. 12 shows the motion picture machine recording the actual motions of the most skilled workman. It also records the subdivisions of each elementary motion. It will be noticed that the floor and background are both marked off into 4-in. squares.

The object of this is to enable us to place the bench in the most desirable location and to see that the workman stands in the most convenient position. Furthermore, it enables us to determine the lengths of all motions.

Figs. 13 and 14 show sections of two typical motion picture films of a workman assembling a braiding machine. The clock can be easily seen in these pictures and by means of it the times of each elementary motion can be determined. In the consecutive views the clock shows elapsed times of three one thousandths of a minute.

Fig. 15 shows a section of a motion picture film with several workmen assembling the same kind of machines. It shows how different operations are recorded at the same time for future study, thus reducing the cost of time study. It also shows how the performance of a number of men on the same kind of work can be compared.

Fig. 16 shows an enlargement of one of the pictures of motion picture films.

From the above it will be realized that micro-motion study enables us

a To capture the experience of the most skilled workman and record it for the benefit of all.
b To determine the motions of least waste.
c To teach the best known methods only.
d To analyze, measure and compare new data so that improved methods may be constantly standardized as fast as discovered.

I believe that the time will soon come when we will have a national bureau of standards of best methods, and micro-motion study will provide a means that the government can use for collecting and recording the best practice of the workmen in our industries.

Robert Thurston Kent. Underlying the three regulative principles given in Par. 41, is a greater one which renders them all effective—the principle of measurement. Micro-motion study is the most powerful tool ever offered the engineer to measure the efficiency of the worker. The moving picture machine together with a specially constructed clock which will measure time intervals to the half thousandth of a minute, presents a means of studying operations or cycles of operations which occur too rapidly for the eye to follow and which, therefore, are impossible of study by the ordinary method of an observer with a stop watch.

Time study is the basis of all modern management. The provision of a machine to make time study should be as revolutionary in the art of time study as was the invention of the power loom in the art of weaving. Among other things it absolutely eliminates the human equation. It provides a method in which there is not only no possibility of error in measurement, but which furnishes at once a true statement of the time elapsed in the performance of any operation and a record and instruction card of the best method of doing a job.

In The Psychology of Management the following statement appears:

> Measurement is a most necessary adjunct to selecting the workers and the managers and assigning them to the proper functions and work. They cannot be selected to the greatest advantage and set to functionalized work until (*a*) the unit of measurement that will of itself tend to reduce costs has been determined; (*b*) methods of measurements have been determined; (*c*) measurement has been applied, and (*d*) standards for measurement have been derived.

It is obvious that micro-motion study at once presents a means of most economically determining and applying all these standards.

It was the writer's privilege to be present at many of the experiments which led to the development of micro-motion study and to observe how it was applied to the transference of skill and experience. Scientific management makes use of the best methods of all trades which can be transferred to the trade under consideration. The experiments under which micro-motion study was developed are an illustration of this point. The work involved was the assembling of braiding machines, obviously a machine shop proposition. The original method of assembly involved the bringing of the various pieces to the job in a box or boxes from which they were taken as required by the worker. Many unnecessary motions were used to transfer the individual pieces to the growing machine which were promptly revealed by the moving picture machine. A bench which would bring the top of the completed machine at a convenient level for the workman was built and the parts were arranged in an orderly manner in bins behind him, thus reducing the number of motions.

In other trades in which some of the experimenters had been engaged it had been found advisable to group the units composing a single assembly on a packet arranging them in the order in which they were needed. This suggested a similar packet scheme for the parts of the braider. A horizontal packet was first made up and the motion picture machine revealed an irregularity and lack of rhythm in the movements of assembling which seriously cut down the efficiency of the workman. A change to a vertical packet and a standard height of portable assembly bench was thereby indicated. On this packet the various parts are hung on pegs in that exact position which micro-motion study has revealed as the most economical of motions both as regards time and length of travel. Micro-motion study revealed the deficiencies of previous methods and permitted the development of the final accepted methods in a small fraction of the time and expense which would have been necessary under conditions existing before its invention.

F. A. Waldron. Literature on scientific management has dwelt largely with the labor problem, while the other elements which tend so much toward maintaining factory output have been to a large extent ignored. Scientific management in its highest sense can be likened to the proper functioning of the human body, in which each part carries its own portion of the load, does its own share of the work at the proper time and distributes energy in proper proportions to all parts of the human frame.

There has been more or less tendency in the management of industries to divorce the financial and sales organizations from the factory or shop management in such an arbitrary manner that the two act in a way indicating that each is working for itself regardless of the broader interests of the company of which each is a part. So long as the sales end can get orders to the factory and be duly credited, the fact as to whether this order contains enough specific information to complete it, is ignored and it is left for the factory to make it out as best it can. A serious loss in volume of output may thus be caused. I can recall several instances in my experience where an output of from $50,000 to $100,000 worth of business was held awaiting detailed information on minor items before the order could be shipped. It is essential to keep the entire organization in balance. Do not overload sale and advertising departments if the factory cannot handle the work. Build up on a solid foundation surely and gradually. Educate not in the factory alone, but along the entire line.

Output. In the excitement of the moment, the quality of output should not be lost sight of. This cannot be maintained by the mere placing of tools, instructions and drawings in the hands of the workman. Men must be trained and it takes time and money to train them. Unless this training embodies the elements of thoroughness and completeness, they become half-rate and slip-shod men, looking for pay day and taking little if any interest in the work.

Ideal factory conditions rest almost entirely on one basic principle which is *constant volume of output.* It is not always possible to maintain this owing to conditions that may arise, such as orders, capital, and the proper supply of materials and help. Every green workman broken in means sacrifice in profits, quality and volume of output. As these weak spots develop, however, we should try to build them up in such a way as to make conditions tending towards constant volume of output, as nearly perfect as possible.

It is far better to work at a steady even gait for a year than to intensify the production to a point where all the work is done in six months and your factory is idle for the remaining six months.

The extent to which time study should be carried depends entirely on these conditions and the expense incurred by ultra-refinement could better be invested, oftentimes, in raw materials or finished stock of proper quality. It is the province of the industrial and efficiency engineer to help guide the manufacturer as to how far he should go into a question of this kind.

A factory with an undersold output is no place for a premium or bonus system. Accurate and simple accounting and routing are requisites here. With an oversold output, a premium, bonus or piece rate system, based on accurate time study, combined with accurate and simple accounting and routing are necessary to produce the maximum efficiency on the shop end, combined with a purchasing, inspection and stock department that can keep pace with a well developed shop organization.

Purchasing. The most effective coöperation between the factory and purchasing departments is as essential as time study or production engineering work. Of what avail is time study and intensified production if the materials the purchasing agent buys at the lowest price will not meet the requirements of the product in quality? Work will either be thrown away before it is assembled, or if sent out in the finished product, it will react on business. The only way is to buy to specifications and see that the material is on hand before it is needed and that the specifications are conformed to.

Low prices paid for materials are not necessarily exponents of a purchasing agent's efficiency. The man who can discriminate and buy the right thing at a fair price is the kind of man that lasts in this period of competition and exacting requirements.

Serious delays and expenses are often caused by incomplete or incorrect specifications for simple materials and supplies. This trouble can be obviated by a symbol or number system which ties all materials used in the factory to a standard specification which is definite and complete in its wording.

Engineering. A product improperly designed and well made cannot maintain its place in the market, and, conversely, a product properly designed and improperly made, cannot be sold. To design properly and to see that it is properly made, is the measure of efficiency of the engineering department.

Proper strength, lines, proportions, tolerations, inspection, instructions, manufacturing specifications, tool design and manufacturing, should be done in this department and done thoroughly. Time study and bonus system are thrown away if done on work that cannot be used, or hurts trade. Further, responsibility is more readily placed if this is done in the full sense and meaning of the word "complete."

The engineering department in the modern organization of high efficiency is the most important of all, as it is the fountain head from which all specifications are issued, designs made and quality of work determined.

Inspection. To assure proper materials being given to the workmen is the first and most important duty of the inspection department, followed by proper tools, condition of machines, jigs and fixtures to assure reasonable performance of acceptable work. These functions are just as necessary to efficient work as time study or bonus system, for without these the intensified production would be lacking, owing to the fact that conditions for perfecting the work would not be constant and the failure to perfect such work would be beyond the workman's control.

After these requirements have been brought up to the proper standard of efficiency, this division can control the quality of the work as specified by the engineering division and is in a position to insist on its quality being maintained.

Maintenance. To do a full day's work a man must have proper light, heat, power machines, tools and fixtures, etc., in proper working condition, and it is up to the management to see to it that he does. One of the most common troubles is the condition of belts, long ago recognized by Fred. W. Taylor and covered in his paper on Shop Management.[1] His system with the belt, bench and scales in a factory using many belts is the best obtainable and shows direct results in volume of output and saving in belt bills.

Countershafts, main shafts, jack shafts, motors, machine repairs, should receive a systematic supervision to insure constant and efficient operation. It is true that time study develops these requirements, but these requirements should be attended to first or time study will in a way be wasted.

Accounting. To have reasonably accurate costs is both desirable and necessary, not only as a means of efficiency but also to eliminate unprofitable articles of manufacture and produce the more profitable ones. This system requires methods of factory accounting which interlock with routing system, time keeping, and stores, requiring a close coöperation with the stores, inspection and producing work of management.

Proper distribution of overhead charges, accurate time study and charges, accurate material charges, controlled from a central point in which all is charged against its proper account by the same mental interpretation is the only accurate way, combined with a symbol method, not too complicated, which places the burdens where they belong at the time the expense is incurred.

Stores. Raw and worked materials must be properly accounted for, and the truthful conduct of a stock room is important and necessary. Stores records should be complete and show enough information to gage efficiency without being so complicated and cumbersome as to require more time to tell the story than an inventory.

Maximums and minimums should be so proportioned as to allow a minimum amount of capital being tied up in fixtures, stock, raw materials and work in process as well as all materials spoiled or defective. A graveyard in a store in plain sight of all is a mighty object lesson to the management and workmen.

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[1] Trans. Am. Soc. M. E. vol. 24, p. 1337

The broad or commercial interpretation of efficiency engineering, or scientific management, is profitable management, in which the final measure of success is the return on the investment. As this return is dependent on other than labor elements, it would seem but fair that we carefully and earnestly consider the fact that no man can do efficient work at a machine unless the conditions are made right for the performance of such work and that each function of the industrial organization requires as close, if not closer, attention on the part of the management than do the workman and the machine.

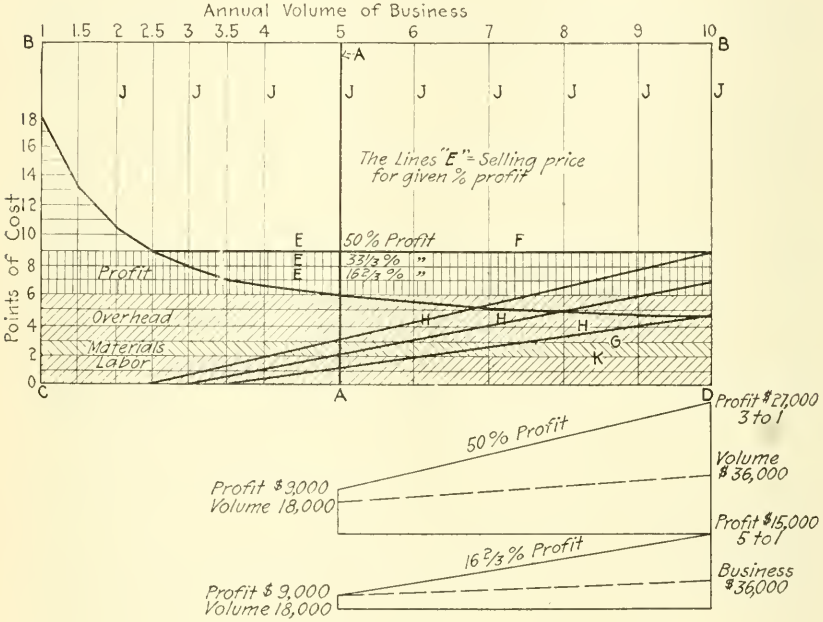

Fig. 17 Diagram for determining Cost of Labor, Materials, Overhead and Profit

Explanation of Diagram. Variations in expense and cost of labor and materials are practically negligible, but each factory or unit of output should have a separate diagram based on actual conditions of costs of flat labor, materials, overhead and profit.

In Fig. 17 *BC* shows the points of cost; *BD* the points of profit; the different percentages of profit are shown by *EE*.

To use the diagram, assume first that the product is sold at a certain price. Then select *E* to correspond to the profit for these price points. Following this line to the left until it intersects the curve, will give the point where the year's business will break even. To illustrate with 50 per cent profit, it will be necessary to do a business of 2.5 per year in order to break even. On an annual business of 5, the profit would be 3. With an annual business of 10, the profit would be 9. Then the dollars and cents profits would be those made on 5 multiplied by 9 and divided by 3.

The line *HH* is drawn from the point of no profit to the point of maximum profit on the basis of 10 for the year's business, or double the average business.

For any given volume of business of the line *BB*, the points profit could be obtained by the intersection of the lines *JJ* with the line *H* and read out to the scale on the line *BD*.

By studying Fig. 17, it will be seen that the cost of materials and the overhead expenses are so great in proportion to the labor performed that more emphasis should be placed in this report on the management end of the factory than on the workman and the machine.

FRED. W. TAYLOR. The preparation of this report has evidently involved careful research, followed by a close analysis of the materials gathered in. The viewpoint from which the whole subject is examined is new and original. Most writers upon this subject have emphasized the necessity of reducing to a science the knowledge which in the past has been in the heads of the workmen. The change from rule of thumb to scientific knowledge has been largely dwelt upon, and its importance pointed out. The thought of the committee, however, centers mainly about transfering this knowledge to the workman after it has been acquired by the management; and from this viewpoint scientific management is very properly summarized as " the mental attitude that consciously applies the transference of skill to all of the activities of the industry."

The Committee very properly calls attention to the significance of the change in the mental attitude of both sides which takes place under scientific management. This would seem to be the most vital element in scientific management. It was, indeed, looked upon as of such importance that, during the hearings before the House Committee "to Investigate the Taylor and other systems of management," man after man came from the shops which are being run under scientific management, to testify that the very essence of this system lies in the great mental change which comes both to the management and to the workmen. In fact, with but few exceptions, these men testified that without this complete mental revolution, scientific management could not exist.

This mental change is great and far-reaching. It means essentially a change from suspicious watchfulness and antagonism and frequently open enmity, between the two sides, to that of friendship, hearty good-will and coöperation. It means a change from the old belief that the interests of employer and employe are in many respects necessarily antagonistic, to the firm conviction that the true interests of the two are mutual.

This feature of scientific management is of such importance that it seems desirable to make one of the causes for the change in mental attitude a little more clear. The following illustration may help to do this:

Into the manufacture of any article there enter two items of expense, the cost of the materials of which it is composed, and the cost of what are commonly called "overhead expenses" or general expenses, such as the proper share of power, light, heat, salaries of officers, etc.

Now, if these two items of expense, cost of materials and general expense, be added together and their sum subtracted from the selling price of the article, we have what is called the "surplus." And it is over the division of this surplus between the company and the men that most of the labor troubles and disputes have come in the past. The men want as large a part of this surplus as possible in the form of wages, and the company as large a share as possible in the form of profits. And in the division of the surplus, under the older systems of management, both sides have come in many cases to look upon their interests as truly antagonistic.

A part of the great mental revolution that occurs under scientific management is the complete change in viewpoint of both sides as to this surplus; from looking upon the *division* of the surplus as the important question, they both come to realize that if, instead of pulling apart and quarreling over it, they join together and both push hard in the same direction, they can make this surplus so large that there is no need to quarrel over its division, because each side can get a far larger sum than they had ever hoped to get in the past. And each side realizes that this result would have been entirely impossible without the hearty coöperation of the other. The workmen see clearly that without the constant help and guidance of those on the management side, they could not possibly earn their extra high wages, and the management see that without the true friendship of the workmen their efforts would be futile, and they are glad to have their workmen earn much higher wages than they can get elsewhere.

The introduction of scientific management is, so far as I know, the first large movement in industrial history in which a great increase in the output of the workmen has been at once accompanied by a large increase in the earnings of the workmen. The great increase in output resulting from the introduction of labor-saving machinery was not at once accompanied by much if any increase in the wages of operatives, and in many instances the introduction of labor-saving machinery resulted in paying lower wages to the operatives of these machines than had been received by similar hand workers before the introduction of machinery. The main profit was absorbed at first in almost all cases by the manufacturers, who introduced the new labor-saving machinery. In the end, of course, the operatives, along with all the rest of the world, have profited immensely through the introduction of labor-saving machinery.

One of the most notable features of scientific management, however, is that the group of men who have introduced it have insisted that the workmen coming under its principles should at once be paid from 30 per cent to 100 per cent higher wages than they could get elsewhere. This fact is not appreciated by the general public, and largely because the labor leaders, consistent in their fight against the introduction of any labor-saving device, have seen fit to misrepresent far and wide almost all of the good features of this system; and in doing this they have strenuously denied that the workmen coming under scientific management are paid higher wages than heretofore. Quotations such as the following, taken from the famous circular distributed by President O'Connell throughout the Machinists' Union, are typical of this misrepresentation by labor leaders:

> Wherever this system has been tried it has resulted either in labor trouble and failure to install the system, or it has destroyed the labor organization and reduced the men to virtual slavery and *low wages,* and has engendered such an air of suspicion among the men that each man regards every other man as a possible traitor and spy.
>
> The installation of the Taylor system throughout the country means one of two things—i. e., either the machinists will succeed in destroying the usefulness of this system through resistance, or it will mean the wiping out of our trade and organization with the accompanying low wages, life-destroying hard work, long hours, and intolerable conditions generally.

In answer to this statement of O'Connell's, however, in the sworn testimony given before the House Committee to investigate the Taylor and other Systems of Management there was presented a schedule of the present wages in comparison with the past wages of all of the workmen who had been more than 12 months in the employ of a company which was using scientific management. This statement showed that the workmen were then receiving on an average 73 per cent higher wages than when they first came under scientific management. The list of employes included all kinds, even the colored men who helped move the materials around the floor of the shop, and the sweepers, etc.

The testimony also showed that the company, after paying this 73 per cent increase in wages, found itself better off than it was under the older type of management. That fewer workmen were turning out three times the output formerly obtained and that the selling price of machines manufactured had been reduced 25 per cent.

It is object lessons of this sort which are rapidly convincing those who investigate scientific management that the interests of both sides are mutual, instead of antagonistic.

The historical portion of the report shows careful study, and is evidently the result of much research. In certain particulars, however, it is somewhat misleading; that portion of it, at least, which includes the quotations from Adam Smith, etc., and particularly Tables 1 and 2, given in the Appendix.

Although the fact is not specifically stated, still the general impression from reading this part of the report is that "time study," which is the foundation for "the transference of skill from the management to the men," was practically carried on in 1760 and in 1830, as it is now under scientific management. This is, however, far from the truth, and in the interest of historical accuracy it may be desirable to make a statement as to the beginning of "time study," although I realize that questions as to who started time study, and when it was started, are of very little consequence, the important questions being, what is time study? and, how shall we make it more useful?

Time study was begun in the machine shop of the Midvale Steel Company in 1881, and was used during the next two years sufficiently to prove its success. In 1883, Mr. Emlen Hare Miller was employed to devote his whole time to "time study," and he worked steadily at this job for two years, using blanks similar to that shown in Par. 367 of "Shop Management."[1] He was the first man to make "time study" his profession.

It is true that the form of Tables 1 and 2, given in the Appendix to the Committee's report, is similar to that of the blanks recording time study, but here the resemblance ceases. Each line in Table 2, for instance, gives statistics regarding the average of the entire work of an operative who works day in and day out, in running a machine engaged in the manufacture of pins. This table involves no study whatever of the movements of a man, nor of the time in which his movements *should* have been made. Mere statistics as to the time which a man takes to do a given piece of work do not constitute "time study." "Time study," as its name implies, involves a careful study of the time in which work *ought* to be done. In but very few cases is it the time in which the work actually was done.

Previous to the development of "time study" in the Midvale Steel Works, there have in all probability been many instances in which men have carefully studied and analyzed the movements of other men, and have timed them with watches. (No such instances have, however, come to my personal attention.) Any such former work was without doubt confined to isolated cases, and was of short duration; and (most important from the historical point of view) it did not lead to the development of a new trade, or, more properly, to a new scientific occupation, "the profession of time study."

Any former efforts of this kind would bear the same general relation to the time study done in the Midvale Steel Works that the many early attempts at flying bear to the work of the Wright brothers.

The Wright brothers started "man flying."

[1] F. W. Taylor, Trans. Am. Soc. M. E., vol. 24, p. 1436.

The Midvale Steel Works started the "profession of time study."

(I do not of course intimate that the two developments are of equal importance.)

Time study is the one element in scientific management beyond all others making possible the "transfer of skill from management to men." The nature of time study, however, is but imperfectly understood and it is therefore important to define it clearly. "Time study" consists of two broad divisions, first, analytical work, and second, constructive work.

The analytical work of time study is as follows:

a Divide the work of a man performing any job into simple elementary movements.

b Pick out all useless movements and discard them.

c Study, one after another, just how each of several skilled workmen makes each elementary movement, and with the aid of a stop watch select the quickest and best method of making each elementary movement known in the trade.

d Describe, record and index each elementary movement, with its proper time, so that it can be quickly found.[1]

e Study and record the percentage which must be added to the actual working time of a good workman to cover unavoidable delays, interruptions, and minor accidents, etc.

f Study and record the percentage which must be added to cover the newness of a good workman to a job, the first few times that he does it. (This percentage is quite large on jobs made up of a large number of different elements composing a long sequence infrequently repeated. This factor grows smaller, however, as the work consists of a smaller number of different elements in a sequence that is more frequently repeated.)

g Study and record the percentage of time that must be allowed for rest, and the intervals at which the rest must be taken, in order to offset physical fatigue.

The constructive work of time study is as follows:

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[1] Recording these movements so that they can be readily found is the most difficult element of time study. The writer threw away his first two years of time study because it was so poorly indexed that he was unable to find the elements when he needed them.

h Add together into various groups such combinations of elementary movements as are frequently used in the same sequence in the trade, and record and index these groups so that they can be readily found.

i From these several records, it is comparatively easy to select the proper series of motions which should be used by a workman in making any particular article, and by summing the times of these movements, and adding proper percentage allowances, to find the proper time for doing almost any class of work.

k The analysis of a piece of work into its elements almost always reveals the fact that many of the conditions surrounding and accompanying the work are defective; for instance, that improper tools are used, that the machines used in connection with it need perfecting, that the sanitary conditions are bad, etc. And knowledge so obtained leads frequently to constructive work of a high order, to the standardization of tools and conditions, to the invention of superior methods and machines.

It is unusual to make a study such as this of the elementary movements of the workmen in a trade. The instances in which this has been done are still rare[1]: And it would seem that this must be due to a lack of appreciation of the great power which is given to the man who possesses a knowledge of the time value of these elements, and also to a lack of appreciation of the large variety of work to which these elements apply. How many men, for instance, know that a man who has received his education in "time study" through analyzing their elements of the movements of machinists engaged in manufacturing conveying and hoisting machinery, can go with this knowledge into another establishment manufacturing machinery not in the most remote degree resembling hoisting machinery, and there use this knowledge to fix accurate daily tasks for the machinists? Yet during the past year and more, a young man trained in time study in the Link-Belt Works in Philadelphia, has been setting the daily tasks in one of our arsenals manufacturing a large variety of war materials, including the great disappearing gun carriages used in our coast defence.

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[1] Most of the men who have made what they call "time study" have been contented with getting the gross time of a whole cycle of operations necessary to do a particular piece of work, and at best they have thrown out the time when the workman was idle, or evidently purposely going slowly.

Surely, when the significance of such a fact as this is appreciated, companies employing machinists, even though they may be manufacturing radically different kinds of work, will join together in studying the rudimentary elements of the machinists' trade and then in publishing this knowledge so that it may be available for hundreds of companies, where now it is the private property of the few concerns who have had the patience and the courage to be pioneers in this field. It is the lack of published data regarding the time required to perform each one of the elementary operations in our various trades (more than any other element) that makes the introduction of scientific management such a slow process.

If we accept the committee's definition of the new management as the "transference of skill from the management to the men," it is evident that the management cannot transfer knowledge and skill until they themselves possess this knowledge, and up to this time each new company introducing scientific management has been obliged to obtain this rudimentary knowledge through their own analysis and study, a very slow and tedious process.

Seventeen years ago, I predicted, in a paper read before this Society,[1] that books would be published similar to our engineering handbooks, embodying a time study of all of the elementary operations occurring in our various trades; and, was then greatly laughed and sneered at for making this statement. Only one such book has as yet appeared, but I wish to repeat my prophecy with more emphasis even than before—that hundreds of books of this sort will be published in the future, and in the not far distant future. These books will make possible "the transference of knowledge and skill from the management to the workman" on a large scale throughout the country, and the introduction of scientific management will then indeed proceed at a rapid pace.

F. G. Coburn[1] said that the committee have expressed in their report the "human interest" side of scientific or labor-saving management, which some of its critics say it lacks. The human part of industrial management, it seemed to him, was the use of certain psychological or psychic influences to cause employes to work hard, loyally and intelligently, and the degree of success attained depended largely on the number of these influences that were correctly used. They have never been clearly defined and are not clearly understood, even by those who use them. When they are defined, the industrial manager will have a set of proximate rules for a game which is at present played without rules.

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[1] A Piece-Rate System, Trans. Am. Soc. M. E., vol. 17, p. 856.

The manager who supports his unconscious use of these psychological influences with known methods of labor-saving management, i.e., worked-out details based on the basic and regulative principles stated in the report, applied to his own plant, is bound to be better off than if he did not.

The system of management is but the tool of the manager. Alone it is useless, may even be dangerous; the management without it is handicapped, whereas the system, backed by an active mind continuously using it, is the effective combination. And labor-saving management is a system that forces the executives to manage.

As at present understood, the expressed principles underlying and regulating labor-saving management do not completely solve industrial management. They may only postpone the strike problem. A prominent investigator of business and industrial problems expressed this by saying that there is no assurance that the increased reward offered to the worker for attaining high production is the worker's correct share of the increased profit. He has his own misgiving as to what would happen were the greater part of a given labor market employed under labor-saving management.

It would seem that coöperation between employer and employes, so necessary to the successful practice of labor-saving management, is based on a bargain subject to change; and that successful readjustment of the bargain would be required from time to time, to insure the continuance of such coöperation. This may settle itself. A noteworthy example of readjustment initiated by the employer in favor of the employes has been recently brought to his attention. He expressed the opinion that the committee's report opened the way to study of psychological principles—or psychic, perhaps—that are involved; and the hope that some day may see a committee of this Society appointed to take up this investigation.

Carl G. Barth. I am gratified with the report as an endorsement of the kind of work I am permanently engaged in; particularly as I find among the names of the members of the committee who have signed the majority report, that of a personal friend who, only through this investigation has become a convert to scientific management. I am unable to take as broad a view of the matter as the committee have attempted, as I am tied down too closely to the daily details and difficulties of the practical introduction of scientific management to devote much time to its broad historical and economic aspects. Part of the report, also, has a rather amusing side for those of us who now for several years past have been working with some success in this field, in that it is virtually a declaration to the effect that the committee has assured itself that there really is such a thing as "scientific management," and that it does accomplish some of the things, at least, which its exponents allege that it does. It reminds me of the farmer who came to town in the early days of the automobile to assure himself that there really was such a thing as a horseless wagon not requiring tracks to run on, and that it actually did carry people around in the streets without running wild and upsetting everything in its way, except when in the hands of a driver possessing more ambition than experience and sense of responsibility.

As regards the minority report, I see no good reason for its coming into being, as it contains nothing that I cannot agree to, and to my mind nothing that it recommends conflicts with the majority report.

It merely asserts that there are places in which, and conditions under which, the introduction of scientific management would not be a paying proposition; a matter that I do not believe anybody will dispute. In fact, experience has long ago taught me that there is hardly an establishment in which there is not some department or corner of the works which is not better left almost untouched by the new order of things, except in the matter of having its relations to the rest of the works properly dovetailed into this.

To take the automobile for a second illustration, I have never heard of anybody recommending its use to the extent of declaring that walking is no longer a profitable and sensible method of locomotion, to be eventually given up entirely; though we also know that some automobile enthusiasts do use the automobile at times and in places where walking would be more appropriate.

As regards the attempt of the committee, and others, to give a more appropriate name to what we all now pretty well understand by scientific management, I like to state that I have until recently preferred to refer to what I am trying to do, as the "Taylor system of management;" and that Mr. Taylor himself was the first one to discourage me in thus using his personal name in that connection, and to suggest substituting therefor the term scientific management. However, as I am not only not ashamed of, but on the other hand exceedingly proud of, being accused of being Mr. Taylor's most orthodox disciple, I have stuck to the former until recently; though since numerous imitators have invented a number of substitute names, so far as I can see to no practical purpose, I have become more favorably inclined to the use of the term scientific management. Accordingly, I now refer to myself as an exponent of the "Taylor system of scientific management," and feel that in doing so I have just about the whole thing.

In his discussion Mr. Gillette tries to point out that Mr. Taylor and his disciples have not covered the whole field and mentions as an example, cost and accounting as a matter to which they have paid no attention. However, the mere fact that Mr. Taylor has not written on every subject of his activities, must not be taken as a proof that he has neglected any important matter connected with the management of an industrial institution. The fact is that Mr. Taylor's disciples also owe him a great debt for the cost and accounting system he has handed over to them, one which for completeness and flexibility stands absolutely unequalled even today, in spite of the great attention this subject has recently received.

Mr. Church also mentions that the study of machines is a matter thus neglected. However, this is also a subject Mr. Taylor gave serious attention over 25 years ago, or about the same time that he first took up the study of the art of cutting metals, and this has played one of the most important roles in the subsequent work done by myself in the perfection of some of Mr. Taylor's methods.

Again, one speaker suggested that there should be a special purchasing agent for buying labor, as if that too were a brand new idea, whereas Mr. Taylor has also pointed out the desirability of that, and as long ago as 1895 gave us an example of it in a man employed by some Western company at a salary of $5,000 a year, who had the buying of labor down to a fine art.

Mr. Gantt has told us about the disastrous results of changing to piecework from his bonus system of paying, in a plant systematized by himself, and I fear that what he said might have been misleading to some of the audience.

There is no question that piecework based on careful time study is the best and most just form of contract between employer and employe, and though I have not introduced Mr. Taylor's differential piece rates for some years past, I still believe that system is the best suggested to date. However, it is so difficult to get employers to wait until all such standards have been provided, and such time-study men have been trained, as are absolutely essential for the introduction of a piece-rate system, that we are usually forced by circumstances to beg the question and to resort to the expedient of a bonus or premium system.

These systems have the advantage of any piece-rate system, and particularly the differential, in that they may be established and give some satisfaction to both parties concerned, long before it would be possible to make a success of a piece-rate system.

However, there is no doubt in my mind, that the differential piece-rate system conceived and used by Mr. Taylor some 30 years ago, is the ideal of all the schemes suggested to date for paying workers in any other way than by straight day wages.

Regarding the use of a moving picture machine for motion- and time-studies, it looks to me to be practically the same thing as was offered to the Watertown Arsenal at the time we took up that part of the work there. I do not remember the inventor's name, only that he was connected with the Navy or with one of the navy yards in one capacity or another. While the scheme was interesting, it was declined after a conference between the commanding officer Mr. Merrick, and myself, particularly on the opinion expressed by Mr. Merrick, who is one of the most experienced time-study men in the country, and because of the anticipated great expense both of procuring and operating such a machine. Perhaps this was a mistake, for no doubt the machine can be successfully used for motion study, and hence for the elimination of useless motions, but I am still open to conviction regarding the use of any machinery of this kind in connection with time study. The two main difficulties in time study are: first, to judge when a worker is working at a proper rate and to make proper allowances when he is not; second, to make proper allowances for necessary rests, etc.; and I do not see how any kind of machinery can help us in these difficulties.

Alex. C. Humphreys. We should discuss frankly the questions that come before us. Professor Thompson in his remarks made this statement: "Referring to the problem of wages, the solution of this problem, if there is one, is not to be looked for from engineers. When an engineer wanders into the field of economics he is apt to bring about the same diverting spectacle that the economist would who would undertake to expound the principles of machine design."

I think that this statement should be met in a meeting of this kind, not in the interest of the engineer so much as in the interest of truth; and certainly so in this particular meeting which is called to consider the subject of efficiency in management. This day's work alone, I think, should be sufficient to contradict effectively the statement to which I object. Again, the record of our industrial life, largely directed and controlled by engineers, serves to contradict the statement. A book economist makes his principal error, and, in my opinion, he has many to answer for in this country especially to-day, in neglecting to consider facts developed in the field of work and so in failing to look on all sides of the question, as necessarily, in my opinion, any man must look; particularly one who is primarily a book man. Unquestionably, the book economist fails in this regard because he is not qualified by practical experience to arrive at exact conclusions.

Finally, after giving this matter very serious consideration for a number of years and having had, I believe, unusual opportunities to judge through my work as an engineer, an industrial manager, and the president of an engineering college, I do not hesitate to say that some of the most inefficient guides as to questions of economics are certain of the professors of economics in our colleges and universities. I trust that Professor Thompson will believe that in this nothing personal is intended.

David Van Alstyne[1] in a communication endorsed the minority report of Mr. Vaughan. Referring to Par. 1*a*, he said that while it may be possible that the application of the newly discovered principles of management to railroads would result in a million dollars a day economy such a statement has no practical value because the application of these principles is impossible at present and will be for many years. The investment required to make possible such economy would be enormous and the change of attitude on the part of railroad owners, operators and employes before such investments and changes in methods are possible will be long deferred.

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[1] 105 West 40th St., New York.

Referring to Par. 1*c*, any system of management which cannot be made acceptable to organized labor is doomed to failure. There is probably no greater problem before scientific managers than to convince labor unions that scientific management has advantages for them as well as for employers.

The term scientific management seems inappropriate because it tends to emphasize the contrast between a system presumed to be based entirely on scientific principles and one in which presumably nothing is done scientifically. Neither wholly scientific nor wholly unscientific management exists and the degree to which management is scientific is the extent to which it endeavors to know what its conditions are, what they should be and how to bring the actual to the standard.

HUGO DIEMER. The report of the committee indicates that in their opinion there is no system of management any more than there is a system of music, chemistry or education.

The committee is to be commended for a strong effort put forth to get at the fundamentals. It should be borne in mind, however, that it is possible to go to extremes in our search for basic principles. For instance, we might consider that the basic principle of mathematics is measurement. If we contented ourselves with this bald statement we would not explain the scope and objects of the science of mathematics as fully as if we extended our definition somewhat.

I believe we should not content ourselves with saying that the principle of division of labor is the basis of manufacturing. If we add to this statement a further one that the principle of division of labor gives rise to such matters as organization, control, specialization and functionalization, we are adding to our definition the sort of matter which we would consider it necessary to add to our definition of the basic principle of mathematics.

Attention is called by the committee to the fact that early writers foreshadowed the planning department, also that motion and time study are not even 19th century products, but that they were known and practiced at the opening of the manufacturing era in the eighteenth century.

The relationship of these isolated cases to the modern science of management is not much more definite than Jules Verne's prediction of the submarine and the aeroplane to the modern perfection and utilization of these ideas. Even in King Solomon's time we had pretty well regulated subdivision of labor, also the eight-hour day with Saturday half holiday and pay checks.

There is no present day science that was not foreshadowed by disconnected parts in earlier centuries. For this reason I would change the definition which the committee has given for the second basic principle, which they designate as the transference of skill. The committee illustrate as examples of this principle the transference of the skill of the inventor to the power-driven mechanism, also the transference of the skill of the real expert in management who trains and directs the persons who are permanently to manage. I believe this element can be better defined by stating that it is the conscious application of scientific methods to all phases of industry, or the conscious effort to build up a science of industrial management. The real science of management will apply research methods, not only to designing and testing but to all phases of industry.

Henry P. Kendall[1] outlined the experiments which have been worked out by the company with which he is connected, in the purchasing of labor, and spoke of the work of the employment man as a particular function in scientific management.

In this establishment this man engages the employes and tries to apply to them whatever physiological test he can to determine the kind of work each is best fitted for, or whether any particular one is fitted for the position for which he applies.

In employing women and girls, all are hired subject to the approval of the factory nurse, and if there is any question as to the health of men applicants, they are likewise passed upon.

So far as any person can judge, employes are given the kind of work for which they are best fitted.

The employment man's responsibility does not cease when he has hired the man. He has to follow his record in his work, and adopting a suggestion that came from James M. Dodge, cards are used to preserve the record of each employe. Four times a year information on each employe is added to these cards, as to how he is performing his work, his aptitude for it, his skill and earning power, and general deportment. He keeps in touch with each foreman or gang boss, and gets a signed report on each employe for these card entries.

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[1] Plimpton Press, Norwood, Mass.

The hiring and discharging and matters of discipline of the factory are all concentrated in the employment man, which prevents the injustice that comes from a gang boss or foreman discharging a man in a moment of anger and saying that he is no good. Should he say that a man was no good, and recommend his discharge, a written report from several quarters might contradict the statement, if it were unjustly made.

The training of young workers is especially important. There is nothing so discouraging to a boy as to be set to work at the end of school by an average foreman and forgotten. He may be in the wrong place and not fitted for that kind of work. He has, in the employment man, one to whom he can go for advice in regard to his present employment, for suggestions in regard to outside education or instruction, one who is in sympathy with him, and with whom he can rest his grievances and feel secure that he will not get in wrong with the boss.

The foremen at first thought they would lose their authority when they could no longer hire and discharge, but now they feel that it rather helps their authority to have the employment man to send to in cases of discipline. When a man is discharged by a foreman, although perhaps for cause, this may be done in an angry manner, and he may leave defiant, and with a determination to "get even." If instead, he is called to the office of the employment man and an explanation is given him as to why his services have not been satisfactory, and he is made to see that he is at fault, and if this is done in a quiet frank way, he leaves with an entirely different feeling. Under this present scheme, the employe is given an opportunity to register just complaints against a foreman, if he has any.

The purchase of machines and equipment has been strongly emphasized. The purchase of labor is more important, but is given less attention. Then, too, the main functions of scientific management can be used only in combination with other functions. This function can be adopted in any concern with equal advantage.

Tracy Lyon suggested that if there is any lack in the report it is in the consideration of the reasons for the vigorous opposition to the new element of management which is mentioned and the absence of permanent results from some conspicuous efforts in this direction. The subject of so-called scientific management is often clothed in glittering generalities which offer no practical suggestions to the average man, but it really means no more than that the manufacturer, operator or business man shall take the time or employ others to consider analytically every condition of his business and every step in his operations rather than to push ahead by mere force of weight. Looked at in this light it would seem that any real opposition to the "new element" must be to the form rather than to the substance and to ill-advised and hasty efforts of "systematizers" in name only. We have yet to discover any royal road leading to efficient management other than through painstaking and persistent effort.

It is difficult to understand a charge, that if a manufacturer's tools are put in the best operative condition and so arranged as to minimize the movement of material, if provision is made for material in definite and sufficient quantities, small tools and other necessities are on hand before the commencement of a piece of work, and a liberal and intelligent measure established for the payment of the workman, the result will not be to the benefit of the employer, the employe and the consumer. The function of a planning system is no more than to provide in advance that the right thing shall be in the right place at the right time, and to distribute the work to the proper tools in such lots that twelve men will not be nursing their jobs with a small amount of material ahead of them, when there is not more than six can take care of. It does not seem as though such a provision could do otherwise than reduce the cost to the consumer.

Any plan of wage payment can be used whether bonus, piece or day work without interfering with the principles of scientific management, provided there is a clear understanding that the employers are willing to pay liberally for a fair day's work. Some of the systems may have been handicapped by the effort to convey instructions to the workmen in too elaborate a manner. The prime requisite is that time study men and instructors should be thoroughly practical and experienced.

Dexter S. Kimball. Ever since the beginning of the present industrial era there has been a growing tendency to separate mental and manual processes and to again subdivide these by the application of the division of labor. The engineering and drafting department was the first direct result and is the best existing example of the separation of the mental from the manual. While the art of industrial management has lagged behind scientific design for natural reasons, its fundamentals are well known and basic data will no doubt soon be available so that we may expect to see it on a more scientific basis.

It is to be noted that the process of "functionalizing" any branch of industry involves no new principle. It is an extension of the general tendency to separate mental and manual processes and motion and time study are not new discoveries as the report clearly points out; but this should detract in no way from the credit due those who have so ably called our attention to the possibility of their more extended use. The ultimate extent to which these principles will be carried and the rate of progress that they will make will depend, however, not on their inherent value or effectiveness alone, but on the growth of public opinion that permits or demands them.

One phase of the discussion touched on in Pars. 62 and 63 deserves more than passing thought. Changed industrial conditions resulting from the separation of the worker from the ownership of his tools have introduced a difficult problem in the matter of the compensation of the employe. The efforts of such men as Halsey and Towne were the first steps toward new methods of rewarding labor. All so called *systems* of management are based on the extension of the principles already mentioned with the addition of some special philosophy of management which invariably includes some variation of these methods of rewarding labor, mixed perhaps, with certain altruistic ideas on the relations between employer and employe and the general uplift of the workman. These altruistic ideas are fine and helpful, though not new, as they were introduced and used by Robert Owen more than a century ago.

Success in the use of these combined methods, whereby better wages and better conditions have accrued to small communities, has led some over ardent advocates of these methods to the hasty conclusion that they really offered a solution of the industrial difficulties which press so heavily upon us. Statements similar to the following are often seen:

"The increase in wages which accompanies this type of management will largely eliminate the wage question as a source of dispute."

"The one cure, the only one for the condition which confronts us is to increase the efficiency of the producer."

That is to say increased productive power *necessarily* means increased profits to the actual producer. But a diligent search through the literature of efficiency engineering will fail to disclose a single new regulative principle bearing on the equitable distribution of the fruits of industry either between the employer and employe, or between the industry as a whole and the ultimate consumer.

Stripped of all sentiment these new methods are exactly similar in operation to labor saving machinery (Par. 37) and their initial and ultimate effects must be similar. They will enable those who first adopt them to obtain some commercial advantage and to pay better wages than their competitors for a time at least. They will also result, if universally adopted, in a considerable increase of productive power; but they in no way affect the fundamentally inherent advantage which must always accrue to those who control the tools of production. They can in no way affect the principle that knowledge of all kinds tends to become common property and for that reason no labor saving device can forestall competition for any extended time. They can in no way affect the law of supply and demand; and even if all the manufacturers in the country were to adopt these methods at once we should continue to see in many places at the same time, storehouses filled with raw materials, idle factories equipped with the finest tools, and people walking the streets without food or clothes and yet willing to work. Labor saving machinery opened the door to tremendous *possibilities* for humanity far greater in proportion than can ever be promised by labor saving management; but it brought with it no self regulating principle which insured equitable distribution of these advantages; and labor saving management is at best a small extension of a great movement.

It is true that all classes of people have profited by the use of labor saving machinery, the actual producer as much as any, and it also follows that in the long run we shall all profit to some extent by increased productive power. But the industrial problems with which we are now wrestling will all be with us till we have made some changes in the basic principles on which we now distribute the results of our labors.

True, all the new systems lay stress on the "square deal" and the coöperation of employer and employe, but these are old as mankind and have always been available as a basis of economic justice in common with all other welfare work. But these measures are optional with employer and employe and do not constitute basic principles. They are exceedingly useful and beneficial as they serve as a means of better understanding of the dual difficulty and as a basis of corrective legislation, which after all is a reflection of the sentiment of the community and grows with it. It is neither fair nor wise, however, to attribute powers and advantages to efficiency engineering which it clearly does not possess. I am not sure but what a small readjustment of some other of our economic problems would do as much for us as increased productive power. We need and need badly some *scientific distribution* and we shall be fortunate indeed if some of the reactive influences now at work on our social and industrial organization will offer some help in this direction before the strain becomes unbearable.

R. R. Keely briefly summed up the economy from the application of scientific management through placing the control of production in a central office. By this means customers are prevented from becoming discontented through having an order handled improperly or overlooked, and there is a saving in time in getting out important orders, in the nervous energy of the management, in material through preventing waste, in losses due to ignorance of the actual condition of the plant in the old system, and in labor due to the planning of all work in advance of its performance, and the best workmen are induced to remain through the creating of contentment and the offering of higher pay.

The "mental attitude" in scientific management, to which the committee refer, is new in that the individual and his work-place are considered, instead of the shop as a whole, as a unit. So far as he knew there had never been a planning room for the handling of the entire work of an industry from a central office previous to the introduction of scientific management by Mr. Taylor.

Joseph A. Bursley called attention to the fact that this was the first time the Society had devoted an entire session to the consideration of scientific management. He was particularly interested in the possibility of applying the principles of this subject to works of educational institutions, especially technical schools, and felt that there was a great field for applying this work in teaching in the engineering schools. The men in the shops connected with the universities, for instance, should be shown the best way of doing each particular piece of work, so that after they are graduated, they may transfer this knowledge to others.

This same scheme could be followed in the laboratories where various tests are made; and even in the class room in the solution of problems of various kinds there is always one way which is the best, requires the least time, and gives the smallest opportunity for mistake.

William Kent. I hesitate to criticize so splendid a report, but I do object to the statement in Par. 37, "The expression 'labor-saving management' better conveys the meaning of the movement." Labor-saving management is but a fraction of the new movement. As I conceive it, the whole question is industrial management, and there are three kinds of industrial management, which some one has called, traditional or unsystematized, transitional or systematized, and scientific management. This third type is industrial management carried on in a scientific manner, and it refers not only to labor-saving management, but to saving of fuel, capital, machinery, wear and tear, lubricants, and everything that enters into the product. I think if a scientific expert were called in by the management of a factory and they should say, "We want your services to show us what we ought to do," he would have carte blanche to go into every department as well as the labor-saving department.

In regard to the statement that has been made to the effect that an engineer who dabbles in economics is going outside of his field, I wish to call his attention to the fact that the first paper mentioned in Appendix No. 2 of the paper, No. 207, written in 1886, was on the topic, "The Engineer as an Economist." The engineer was an economist in 1886 and long before that. Part of the education of the engineer, and no small part, is education in economics. The thoroughly educated engineer must be a political economist and when he dabbles in questions of economy, he is right in his own field and is not going outside of it at all.

H. H. Vaughan explained his objections to the majority report He differed from the report because it definitely advocates certain things, such as the bonus system, the planning department, functional organization and time studies, as constituting the new way in which to run industrial establishments. No one could value Mr. Taylor's work more than he, but his methods had their limitations like most new discoveries. It is a mistake to think they will revolutionize everything and supersede all other systems.

One thing in the report was very interesting to him, the remarks of James Nasmyth, quoted in Par. 9, in which it is stated: "The characteristic feature of our modern mechanical improvements is the introduction of self-acting tool machinery. What every mechanical workman has now to do and what every boy can do, is not to work himself, but to superintend the beautiful labor of the machine. The whole class of workmen that depend exclusively on their skill is now done away with." He thought that a good instance of how a man's ideas that a new discovery is going to take the place of everything that comes up is frequently limited by his subsequent experience. There are more skilled men in Nasmyth's shop today than there were at the time that Nasmyth wrote these comments.

In his minority report Mr. Vaughan used the phrase, "art of management." There is essentially an art in these things, and one cannot give the rules that make an art. There is more in the creating of a successful shop than the studying of a set of prescribed methods. There must be the peculiar intuitive judgment that comes from experience and from the contact with men.

He said further: "Transference of skill," referred to in the report, means in one place doing away with skill, in another the improvement of skill, and develops into the idea of telling the men how to do everything. It is commercially absurd to assume that we will reach the point where we instruct the men in everything. I believe in experts in the shop, but the experience of the men in the shop must be taken into account. Anybody who has started to build a machine or produce any other class of work with new and unskilled labor, has found to his cost the value of the skillfulness of their men as an asset.

The report advocated functionalizing. Instead, I believe in putting more responsibility upon the foreman, making him the head of the units. Functional management is very much like departmental management on a railroad as opposed to divisional management. The most successful railroads are managed on the divisional system.

We do not expect a divisional man to know everything, but we work through him with the staff department, and want him to be the boss of his unit as far as possible. In that way we certainly get results, quicker action in the case of emergency than where the departmental system is in use and where one must go through a lot of routine to get results. Suppose we have a rush order. One man is put in charge of the job, who follows it through department after department, to see that the work is properly done. We could not do that if each department had to be called upon through its head to coöperate to obtain the results. The best results in our shop have been obtained by putting the work up to the superintendent or foreman and leaving the matter in his hands.

With our piecework system the object is to advise the foreman of what is being done rather than of what has been done. We have obtained good results by putting on a man whose duty it is to advise the foreman from time to time as to what is being done so that he can take immediate action in case any men are failing to make the time expected, as governed by the records in the operation of the shop.

As to the question of fairness in dealing with labor and cutting prices, much of this is really due to the fact that the workmen of to-day will not stand cutting prices. A few years ago men were less independent and many shops were operated satisfactorily on straight piecework and with cutting prices. There is no use in pretending to be altruistic in this matter. We have been forced to our present position by experience and it is pleasant to know that we can truthfully say to ourselves that it does not pay to cut prices.

We have been building the same class of locomotives for five years under the ordinary piecework system, and by dealing with the men fairly and encouraging them and getting them interested, the hours have dropped from 100 per cent to 68 per cent.

We believe in the piecework system with a guaranteed day rate, and do not use the bonus system, although in my opinion it is better than piecework where the operations are comparatively simple and the conditions standardized. However, the system must appeal to the men, and if they do not understand it the same degree of success will not be secured.

We are using time-study work to a large extent, and I think time studies are of great value in perfecting a shop. On the other hand we had a shop with a pay roll of $4000 a month get into bad conditions. We sent a couple of men there, with a few good demonstrators, picked it right up, and it began to turn out the output. That is better than if we had been depending on a long-drawn-out system; it is a question of personal influence and quick action. The influence exerted in that case will be felt for a long period to come.

As Mr. Gantt has stated, he introduced time studies in our shops, which we value highly. Our results in the time-study work have cost on the average $600 to $800 a month, since we started, and we are now saving $2000 a month on a pay roll of $35,000, contract work. There has been a satisfactory progression with time study, not a revolution; we would not be without it, but, on the whole, it has not been as important as the piecework system.

There is, moreover, certain work in which day work is preferable to piecework. We would not think of putting steam-shovel repairers on piecework. We would rather have them work day work. We must use day work in certain cases and we should then do all we can to help the men to get the results.

We believe that we should not have any more system in our work than we can get along with nicely. We would rather have too little system than too much in the operation of the shop. We think that the best results are secured not only by studying the conditions, but also by studying the men who are operating the shop.

Thomas R. Woolley[1] considered that the benefits from scientific management had not been all that could be desired for the worker, the manufacturer or the consumer. The worker is dissatisfied because of the strain put upon him to increase his speed and the stop watch in particular causes dissatisfaction. If instead of taking the initiative away from the worker, the rule could be reversed and the initiative of the individual encouraged under the guidance of competent executives, the system would have permanent results.

While the manufacturer has been benefited in some cases, in other cases he has been driven into bankruptcy on account of the large overhead burden introduced to carry out effectively the system, particularly where the business fluctuates greatly from year to year and from season to season. Under such circumstances, it is questionable whether it pays to train workers only to let them go during a dull season or to carry them on the pay roll working inefficiently during that period.

Further, the public had not been benefited by the adoption of the system and the writer cited a case where a large order for steel was placed, after securing bids from different firms, one of which employed scientific management and whose bid was higher than those of its competitors.

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[1] Efficiency Engineer, Boston, Mass.

Dealing with Mr. Taylor's example of training men to carry pig iron, he believed that a fraction of the money spent upon labor saving machinery with an electro-magnet in connection with a crane would give better results at less expense.

In considering whether to install scientific management, a manager must determine whether there is enough of one class of work to make it pay him to train men; whether his plant runs continuously throughout the year; whether it will pay to add a corps of men to instruct his workmen; and whether he should consider that it would pay better instead to install the latest improved machinery for the particular class of work to be produced.

Mr. Taylor and his associates are to be commended for stimulating thought along the lines of eliminating movements, etc. Some of these principles can be applied in a plant but all can not be applied in all plants because of varying conditions.

H. K. Hathaway wrote that the essence of this report lay in the phrase (Par. 29), "The mental attitude that consciously applies the transference of skill to all the activities of industry," further qualified by the statement, " the novelty of the new management lies in this transference of skill from the management to the workman.

This viewpoint is so novel that one is led to question whether the older descriptions of the essence of scientific management may not have been wrong. The committee, however, are merely laying emphasis upon one of the elements which has heretofore been looked upon as rather of secondary importance.

Before skill can be transferred, the management must gather in and record the knowledge and skill which were formerly widely diffused in the possession of a great number of workmen, and much of which was an almost unconscious inheritance. Gathering in and systematizing this knowledge ready for use, constitutes the development of a science to replace the old rule-of-thumb knowledge: this is what has been called by other writers the first of the four principles of scientific management, and this point the committee recognize in Par. 47.

The writer's experience leads him to feel that the committee has not given sufficient prominence to the element of acquisition of skill or "the development of a science" as it has been termed. Such development goes farther than the acquisition of existing skill and results in additions thereto as well as improvement in methods and machinery, and the establishment and maintenance of standards.

It is impossible to transfer skill from the management to the workman first without choosing carefully the workman who is fit to do a particular kind of work, and then training him until he acquires skill: the second of the principles of scientific management. It is not only a transference of skill, but in one sense the creation of skill as well; perhaps a better expression would be the development of latent skill.

The third principle of scientific management has been called "bringing the science and the scientifically selected and trained workman together," which is merely another name for the committee's statement, "the mental attitude that consciously applies the transference of skill to all the activities of industry."

The fourth principle of scientific management has been defined as "an almost equal division of the work and responsibility between the management and the workmen. The management takes over all work for which they are better fitted than the workman, while in the past almost all of the work and the greater part of the responsibility were thrown upon the men." This principle also follows directly the moment the management accept as their duty the first, second and third principles of scientific management. The burden of developing a science where only rule-of-thumb knowledge existed in the past, and the burden of training, teaching and transfering skill from the management to each workman in the place, of necessity calls for an almost equal division of the work between the two sides. So that in the one definition of the new science, by the committee, are implied all of the four principles of scientific management.

It might be proper to point out, in order to avoid misunderstanding, that specialization of workmen on one comparatively simple operation is not necessarily in accord with the best and most economic practice in management. It is a serious mistake and a disadvantage to have operators "unskilled except in a single readily mastered operation" as in the instance cited in Par. 8 of the committee's report. The writer's experience has been that it is not only generally desirable, but in many cases necessary to economy in manufacture, that each operative become skilled in at least two and generally more of the operations making up a process of manufacture. This is an objection to overspecialization purely from the standpoint of production.

Sanford E. Thompson. Criticism is frequently made of the amount of mechanism required to handle the work of modern management, the number of clerks needed, and the consequent increase in overhead charges, and to a visitor this increase in office is indeed more noticeable than the decrease in number of workmen or the increase in production.

If it were possible in a given establishment simply to make a few time studies and set scientifically accurate rates or tasks so as to obtain maximum production, no objection would be raised to the installation of scientific management, although it is obvious that if such a plan could be arranged, it would have long ago been adopted without resort to laborious study. Yet the criticism is heard so frequently from men of intelligence that it is worth careful consideration.

If we refer to the list of papers selected from the Transactions, and given in the Appendix to the report, it will be seen that those presented earliest discussed methods of setting rates for paying men. Following a short general paper by Mr. Towne in 1886, there are two papers on Profit Sharing, the least intricate form of incentive to the workmen; then from 1890 to 1903, the question of payment is discussed more in detail, the premium plan, piece-rate and bonus systems; then come subjects relating more specifically to the more general problem, the management of the plant. It is evident from these papers that this sequence is not chance, but represents a development, not of theory but of absolute necessity in shop management.

A man who has made studies of workmen and introduced piece rates or tasks on accurate detail time study instead of by the usual "fix and cut" methods, finds that the very requirements of accuracy lead necessarily to standardization of methods. It is necessary to plan out the work of each man, to instruct him in the method so that he may use the least material and accomplish his work in the smallest practicable time, and to install a system of cards and records specially adapted for keeping track of the materials and the time of the men.

The development of what Mr. Taylor terms the mechanism of scientific management is thus seen. This development indicates that the broad general principles of planning, routing, instruction, scientific analysis, time study and standardization do not represent a mere system for which some other system may be substituted with equally good results, but a plan which is of broad application in management. These things appear to be fundamentally necessary for any organization which proposes to set rates and tasks which will give the men payments based strictly on the actual work which they accomplish, and which will enable them to do the work with the minimum waste of material.

The practical necessity for the introduction of these individual features is very plain to anyone who makes a scientific study of any operation for the purpose of setting tasks.

These statements may be illustrated by one or two examples from actual practice:

Take the trimming of large sheets of paper to make ready for the press. The machine consists simply of a bed plate about 5 ft. sq. at a convenient level above the floor and an adjustable knife running across this bed plate and operated by power. The operator takes the paper, places it on the bed plate, makes the cuts and transfers the paper back to a truck: a very simple operation, lifting paper, cutting, lifting off.

When the work is studied with a view to putting it on the task basis, the following facts are discovered: The cutter is capable of going through a thickness of about 5½ ins. of paper. The size of the paper on the particular machine referred to is large, running up to 40 in. by 60 in. On account of the weight, therefore, the operator has to put it on in several lifts. Since the lift off is easier he is able to take it off in a fewer number of lifts. The number of lifts in both cases is not directly proportional to the weight. It is dependent also on the size, the stiffness, the thickness and the surface finish of the individual sheets of paper. It is readily to be seen, if a man takes six lifts where he should take four, as he naturally will do if he wishes to shirk, the time of lifting and therefore the cost of this part of the work will be 50 per cent too great. It is necessary, therefore, before establishing a task to standardize the plan of furnishing the paper. The paper was always counted, but instead of the usual plan of counting by hundreds, it is now arranged to divide the piles by slips of paper into individual lifts which a man should take.

For determination of the amount of lift and the other variables, special studies were required. These studies took rather more time and skill than the actual setting of the tasks when this preliminary work was accomplished. After the tasks were finally set and put into operation, it was necessary to throw out of commission the other cutter, which had been working on part time, and the only difficulty experienced was in finding work enough for this one cutter to do. As a result, the cost of the work was reduced 30 per cent with, at the same time, an increase of 40 per cent in the pay of the workman.

This is by no means an exceptional case. It is always necessary first to standardize the machine and the methods. It is this as much as anything else that differentiates scientific from rule-of-thumb methods. Usually the direct results of standardization produce even a greater saving than the actual task and bonus.

Another illustration may be taken from a shoe shop. In the cutting of leather, or in cutting linings from cloth, it is a simple matter to make time studies and determine the time required by the men to pick up the die and make the individual cuts. Piece rates may be easily set, based on the output of each cutter. Suppose, then, that this is done and such rates are set. The men immediately begin to " speed up," but in doing this without any restraint they naturally use more material than is necessary. Now, in the case that the writer has in mind, the raw material used in a certain shop during a week averaged $50,000 in value. The labor cost of cutting this material averaged $280. A 10 per cent reduction in the labor cost amounted to $28, while a 1 per cent reduction in material cost amounted to $50. Instead of gaining money by the setting of rates, the plant would actually lose money, because the men would waste more material. It was necessary, therefore, at the start, before setting any rates to attack the quantity side of the problem, investigate the best plan for layout of dies on the machine and establish some method for fixing the amount of material used by each man. This involved eventually a definite planning of each man's work, so as to show him how to use the minimum amount of material; a routing system, as an absolute requirement, which would properly deliver the materials to him and take away his product; and a system of instruction and time cards, so as to handle the work in the smoothest manner possible.

It may be claimed that these are special instances which do not often occur, but experience shows them to be very simple cases. Wherever a machine or an operation on construction work is studied thoroughly in order to eliminate unnecessary operations and the waste of materials so far as possible, similar methods must be gone through and a more or less complicated system adopted for the proper handling of the work. Only by such thorough study and investigation can the operation be reduced to a routine which will be essentially automatic.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

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The Editor will be pleased to receive inquiries for further information in connection with articles reported in the review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

The abstracts of articles on agricultural machinery, in particular motor tractors, have attracted so much interest, as evidenced by the inquiries received from readers, that as far as feasible a regular section will be devoted in the Foreign Review to articles dealing with this class of machinery. Arrangements are being made by the Library of the Engineering Societies to secure the most important foreign publications that will be of use in this connection.

THIS MONTH'S ARTICLES

The Odkolek parachute described in the section of Aeronautics is of particular interest, owing to the rapid and apparently reliable action of the apparatus and the fact that it promises protection to the man flying at low altitudes, i. e., just where safe volplaning to the ground is the least possible. In the section Hydraulics a brief note is given on an interesting mathematical investigation of permanent irrotational motion of a heavy liquid in two dimensions, of interest also to the designer of carbureters, because the same equations apply to a certain extent to the flow of fuel through the carbureter opening. The Kromhout heavy oil engine described in the next section, is interesting both on account of its great simplicity and fool-proofness, and because it uses an improved system of hot chamber ignition. In the same section attention is also called to the description of autogenously welded steel cylinders, with their better efficiency, saving of two-thirds in weight of the engine, elimination of pattern costs and scrapped castings, and higher reliability of work turned out. In the Pieper gasoline-electric car a device is described for regulating the fuel supply automatically in such a manner as to make the gas and electric motive units work always in a way to secure the best overall results.

There are several abstracts of interesting articles on pumping machinery, air and water, special mention being here made of the data of tests of water-jet pumps in Germany and description of the Neumann involute pump claimed to eliminate some of the usual power losses and give an efficiency of 78 per cent. In the section

Steam Engineering, articles will be found on the Babcock & Wilcox superheater, tests of Wilton closed ashpit furnaces in Germany, discussion of hollow water-cooled grates, and new German furnace types, while in the next section may be mentioned articles on the testing of balloon cloth, description of apparatus for the determination, even in a small shop, of hardness of materials by the drill test, and emergency methods for testing lubricating oils. Two articles deserve special mention: that of M. Leblanc on the realization of high angular velocities and of M. Jakob on specific heat and specific volume of steam. The first is only partly abstracted in this issue of The Journal, and is of interest not only to the mechanical, but also to the electrical engineer, the latter having already to do with apparatus running at 20,000 r.p.m. and facing the probability of having to employ still higher speed in high frequency alternators for wireless work. M. Jakob takes up the same problem which Professor Goodenough discussed in The Journal for March 1912, from a different point of view. The notice on the exchange of apprentices between manufacturing plants is also worthy of attention, as it appears to solve to a certain extent the problem of allowing a trained apprentice to see something of the world, which a young man is usually anxious to do, and come in the end to his old plant without feeling as if his coming back was due to his failure to get a good job elsewhere. In the German plan, on the contrary, the man comes back when he can say that he is a fully grown up man, and has come home to settle to his life work.

Aeronautics

"Drzewiecki" Aeroplane with Natural Automatic Stability (*L'Aéroplane "Drzewiecki" à stabilité automatique naturelle*, P. James. L'Aérophile, vol. 21, no. 2, p. 26, January 15, 1913. 3 pp., 5 figs. *de*). Description of the Drzewiecki aeroplane and data of some of the tests made for obtaining the data used in its design. It is probably the first aeroplane designed entirely from data obtained in an aeronautical laboratory (the laboratory of Mr. Eiffel, Champs-de-Mars, Paris, France) for that specific purpose. The principle of the natural automatic stability or rather self-stabilization consists in providing the airship with two pairs of planes arranged in tandem and selected in such a manner with respect to profile, dimensions and incidence that the load carrying capacity of one pair of the planes increases and decreases with incidence more rapidly than does that of the other pair of planes, thus producing a couple counteracting any tendency towards perturbations of equilibrium. It necessitates, however, a selection for the second pair of planes of a profile such that the load carrying capacity should vary but slowly with incidence, and the reverse for the other pair of planes, and this in its turn required a series of preliminary experiments for the determination of the various constants of the planes. The apparatus has not flown yet; but its model, when tested at the Eiffel Laboratory, is said to have shown a remarkable ability to preserve its equilibrium. (For details see *Scientific American*, February 8, 1913, p. 137, and *Scientific American Supplement*, February 8, 1913, p. 89).

A NEW PARACHUTE FOR AVIATORS (*Un nouveau parachute d'aviateur, L'Aérophile*, vol. 21, no. 1, p. 12, January 1, 1913. 1½ pp., 4 figs. *d*). The majority of parachutes require a certain height of fall before they unroll and begin to act, which makes them practically useless in case of a fall from comparatively small heights. In the tests of the parachute described below and invented by Mr. d'Odkolek, it opened after a fall of only 2 m (say 6 ft.). The apparatus (Fig. 1) consists essentially of a gun *A* with a cartridge at the bottom, and disc *B* over which is placed an arrangement *C* like a three-barrel revolver, and still further above it the furled parachute *D*. The axis of the disc is represented by the steel rod *E* which is also the projectile of the gun *A*. To start the apparatus, the aviator pulls the rope *m* which loosens the trigger *f* which in its turn sets off the cartridge; the same pull on the cord sets off also the cartridge placed in the gun *C*. In the latter case, however, the explosion acts at once on three barrels arranged starwise and having for projectiles three small steel cylinders attached by strings to the sides of the parachute. A very efficient shock absorber takes care of the recoil of the gun *A*. When the aviator pulls on the rope *m*, the explosion in *A* projects the disc *B* which pulls the rope *n* and thus produces an explosion in *C* the latter throwing at angles of 120 deg. to each other three projectiles and thus opening the parachute.

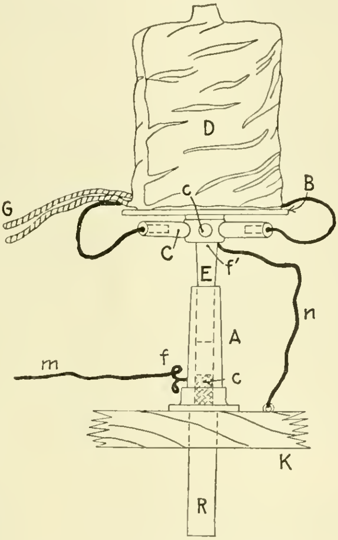


FIG. 1 D'ODKOLEK PARACHUTE

Air Machinery

COMPRESSED AIR LOCOMOTIVE IN MINE WORK (*Die Druckluftlokomotive im Grubenbetrieb*, Hans Wunderlich. *Die Fördertechnik*, vol. 6, no. 1, p. 9, January, 1913. 3 pp., 3 figs. *dh*). General discussion of the use of compressed air locomotives in mines in Europe and the United States.

COMPARATIVE INVESTIGATION OF WATER-JET AIR PUMPS (*Vergleichende Untersuchungen an Wasserstrahl-Luftpumpen.* Grunewald. *Zeits. des Vereines deutscher Ingenieure.* vol. 56, nos. 49 and 50, pp. 1975 and 2011, December 7 and 14, 1912. 17 pp., 35 figs. *eA*). It is hardly possible to build commercially efficient *water-jet air pumps* without experimenting on the testing stand. The problem of the entrance of air between water pistons or water bands is a very complicated one, and many of the theories proposed to elucidate it had to be abandoned after thorough tests to prove them have been made. The first problem of the designer is to drive the water through the pump with as little loss of power as possible: this is so important because the power taken by the water exceeds by far that taken by the air. The greatest losses occur at the place where air mixes with the water, or on the way from the blade wheel to the passages leading to the diffusor and located in the stationary wheel. The tests described in this article have been made with the pumps working on air only; in condenser plant work the pump has also to handle steam which is condensed by the water and lowers the apparent efficiency of the pump. This cannot be shown by figures, but must be borne in mind as one of the advantages of the water-jet pump as compared with dry pumps.

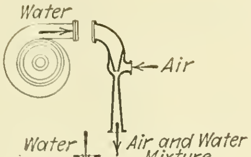
The tests were of a comparative character and had the purpose of determining not only the working capacity of each pump tested, but also its consumption of power per unit of work done. All the air handled by the pumps was measured by the same control nozzles, and the Zeuner and Grashof formula for the determination of the weight of air, in grams per second, was used:

$$G = 397\, q\, F \frac{p'_a}{\sqrt{T_1}}$$

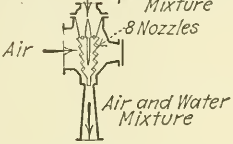
$$G = 0.522\, F \frac{p_a}{\sqrt{T_1}}$$

where G is the weight of air, in grams, flowing through the nozzle per second; F cross-sectional area of the nozzle in qcm; p_a or p'_a pressures in mm mercury in front of the nozzle. The weight of air handled per second is given by Fig. 2B. In determining the efficiency of the pump the author protests against taking into account the air contained in the water and intimately mixed with it. The amount of such air may be quite large, especially when the tank from which the water is taken is small, but this air does not represent useful work done by the pump, and therefore should not be counted.

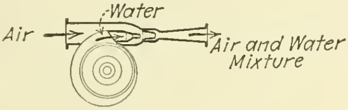
The amount of air in liters (1 liter = 0.03531 cu. ft.) is shown in Fig. 2C. In the neighborhood of the axis of ordinates, i.e. at high vacuums and small nozzle cross-sections, the curves in the figure show a peculiar behavior. When the nozzle is closed, the weight of air sucked in is $G = 0$, and



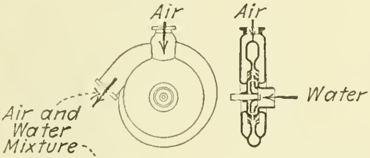
Simple cylindrical water-jet. Pump separate.



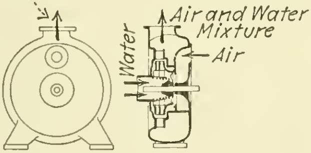
Multiple cylindrical water-jet. Pump separate.



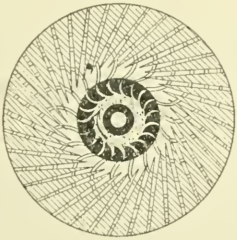
Cylindrical water-jet. Centrifugal pump in one piece with the jet apparatus; full admission.



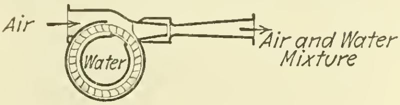
Centrifugal pump with full admission, a very thin disc-shaped water-jet and bladeless wheel; one nozzle wall stationary, the other movable.



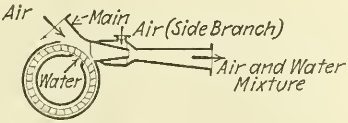
Centrifugal pump with full admission; blade wheel and nozzle ring. Water is taken up by the wheel by suction in many fine jets, and mixes with the air to be sucked before entering into the movable blades.



Centrifugal pump with full admission, and formation of water pistons in the blade wheel. Compression in the stationary wheel.

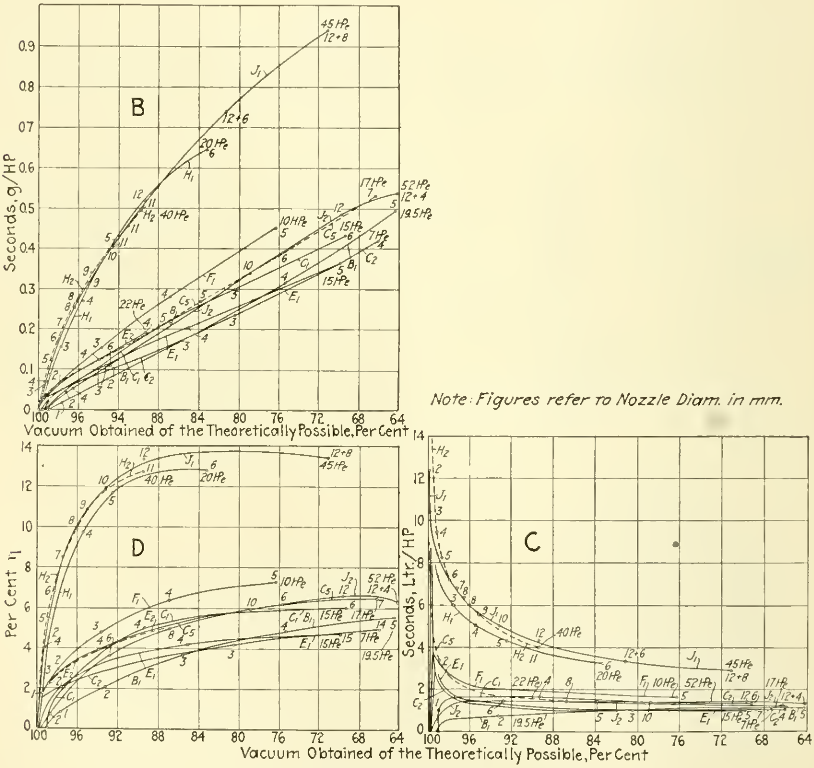


Centrifugal pump with full admission and formation of water piston in the ejector cone; compression in the diffusor.



Same as the previous type, but with double air drawing off.

therefore the volume of air $V_1 = 0$. The curves in the neighborhood of the origin of ordinates cross the axis of abscissae, then rise to some maximum value, not determined, and continue regularly from then on. The curves of Fig. 2C show that with zero nozzle a vacuum is obtained nearly equal to that which corresponds theoretically to the given temperature of water. To indicate the quality of a pump by saying that it can handle so much air per second, and to consider in this only the maximum point on the curve, is misleading, since it is also essential to know how the curve runs in the falling branch, the only one of importance for practical purposes.



Note: Figures refer to Nozzle Diam. in mm.

Fig. 2 Water-Jet Air Pump Curves

Fig. 2D shows the efficiency of the pump η which is the ratio of the work N_i used for isothermal compression to the work N_e delivered at the pump shaft. The tests have fully proved the isothermal nature of the air compression in the pump (the heat is entirely taken up by the water, and, owing to the large mass of water, the heating of the air is so slight that no appreciable difference in temperature between the entrance and outlet sections could be discovered). As to N_e, the author shows that the curves representing it as a function of the nozzle area run nearly vertically, or that the amount of power taken at the pump shaft is practically independent of the nozzle cross-section. In fact some pumps of smaller dimensions show a better efficiency than larger units of the same construction.

The various types of pumps investigated are indicated in Fig. 2A. The original article contains full data of the tests which cannot be reproduced here owing to lack of space.

Hydraulics

ALUMINUM WORKS OF VIGELAND NEAR VENNESLA IN NORWAY (*Die Aluminium-Werke Vigeland bei Vennesla in Norwegen*, G. Wüthrich. *Schweizerische Bauzeitung*, vol. 61, no. 2, p. 15, January 11, 1913. *d*). Description of the Vigeland hydroelectric plant and the 2000-h.p. Francis turbines used. The Bell-Criens governor is used and fully illustrated (Cp. *The Journal*, May, 1912, p. 792).

PHOTOGRAPHIC INVESTIGATION OF A PELTON WHEEL (*Photographische Untersuchung an einem Peltonrade*, R. Katzmayr. *Zeits. für das gesamte Turbinenwesen*, vol. 10, no. 1, p. 7, January 10, 1913. 3½ pp., 7 figs. *deA*). Description of the apparatus used by the author for photographically investigating the flow of water in a Pelton wheel. The system of photographing is interesting, although not entirely satisfactory. It was found that the water jet as it comes from the nozzle is prismatic; it is divided, without being atomized, in two by the division plate of the double blade, and flows in a compact mass through the Cazin opening on to the second set of blades.

ON THE FLOW OF HEAVY LIQUIDS (*Sur l'écoulement des fluides pesants*, H. Villat. *Comptes rendus de l'Académie des Sciences*, vol. 156, no. 1, p. 58. 3 pp. *m*). The author derives what may be called a general integral of permanent irrotational motion of a heavy liquid in two dimensions. His formulae apply to the flow of a liquid from an overflow, or a jet flowing through an opening in a solid wall, or a similar jet meeting an obstacle which may or may not divide it in two, and in general to all problems where the region occupied by the moving fluid may be represented, e.g. on a circle, in such a manner that the images of the solid walls in their entirety on one hand, and the images of all the free lines on the other hand, divide the limiting circumference in two distinct arcs. A rather complicated mathematical equation is derived which, judging by its appearance, cannot always be integrated in finite terms; when, however, the hydrodynamic problem itself, to be solved by the author's equation, is characterized by a geometric periodicity, the solution may be simplified by the application of the Fredholm equation of the first class, non-singular, and an integration in finite terms can be obtained.

Internal Combustion Engines

HEAVY OIL "KROMHOUT" ENGINE WITH IGNITION CHAMBER (*Moteur à huile lourde "Kromhout" à chambre de combustion incandescente*. O. H. Wildt. *Le Génie Civil*, vol. 62, no. 14, p. 261, February 1, 1913. 4 pp., 11 figs. *d*). For short runs on internal rivers and channels in Holland there is a demand for an engine that should be simpler and cheaper than the

Diesel engine. It should also be of very rugged construction, not require an engineer to run it, and use heavy oil, gasolene being too expensive for the purpose. The firm D. Goedkoop, Jr., of the Kromhout works, Amsterdam, Holland, have designed for this particular purpose the engine which they called "Kromhout" (Fig. 3 A). It works on the two-stroke cycle. In its upward stroke the piston takes in air through the leather flap valve *A*, and compresses it on the downward stroke in the air-tight carter *B* to the

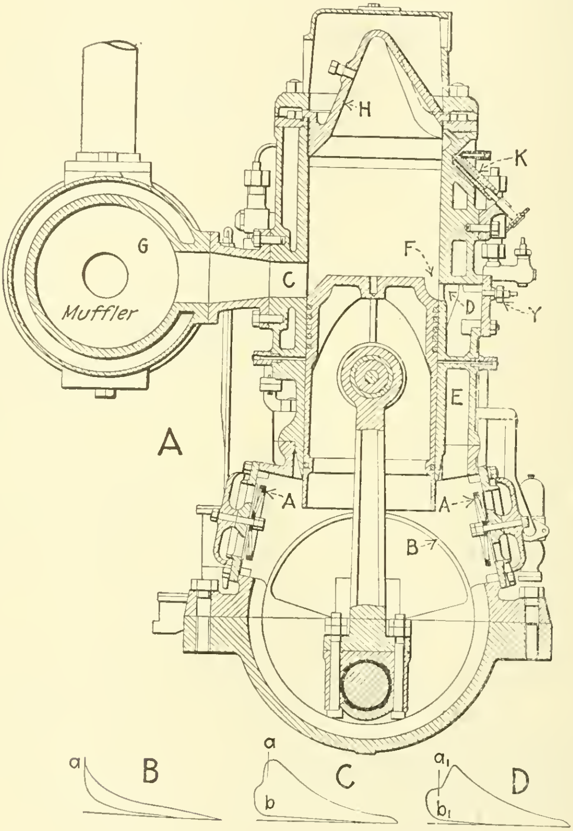


Fig. 3 Kromhout Heavy Oil Engine

moderate compression of 250 to 300 gr. per qcm (3.6 to 4.3 lb. per sq. in.). When the piston reaches the end of its downward stroke, it opens first the ports *C*, lowering the pressure of the gases of combustion down to atmospheric, and then immediately after the ports *D* which admit through the ducts *E* the compressed air from the carter into the cylinder. The notch *F* in the piston is of such a shape as to direct this stream of air upwards, and the air drives out the rest of the products of combustion.

The use of pure air (not mixture) for scavenging eliminates the possibility of loss of fuel in this connection. The compression chamber has the cast steel cone *H* which is heated to red heat by a special burner before the engine is started. The injection of the fuel through *K* begins at the end of the compression stroke, when the crank is about 30 deg. in advance of the dead point, and continues to the end of the stroke. Due to the action of the red-hot walls of the cone *H* and growing compression, the fuel is first vaporized, and then, at the dead center, the explosion takes place, the working stroke being the downward one. A hit-or-miss governor is used. Except in the smallest sizes, compressed gas is used for starting. The engine has neither poppet valves, nor slide valves, and no separate ignition. It can run in either direction, as started. It may be reversed by stopping the supply of fuel for some time and then renewing it when the piston is sufficiently in advance (practically what is known as reversing on the advance ignition). Since, however, this requires time, skill, and is somewhat uncertain in operation, the designers use a reverse gear.

The characteristic element of the Kromhout engine is its ignition chamber. The heat developed by the explosions is sufficient to maintain the cast steel cone red hot. There is even danger that at full load the cone will become so hot as to cause pre-ignition. To avoid this, water is injected from *Y* into the duct *E* which connects the carter and the cylinder. This water is taken from the cylinder jacket when the vessel is in sweet water, or from a special tank when at sea. The water reaches the cylinder in the form of a fine spray, and cools down the mixture as well as the cylinder walls and ignition cone. The amount of water injected is regulated by a special graduated valve. To determine the influence of the temperature of the ignition cone on the working of the engine, a series of tests were made at the laboratories of the builders of the engine, from which the three diagrams in Fig. 3 are reproduced: *B* is the normal diagram of the engine (it shows but little as to the phenomena of explosion, as they all occur too close to the dead point, where the piston is nearly stationary: region *a* of the diagram); *C* is the diagram taken with the ignition chamber too hot: the explosion takes place before the piston reached the dead point (*a-b*), and the engine is slowed down. The opposite happens with *D*, the diagram with the ignition chamber too cold, nearly black: here the ignition is considerably retarded. The best ignition was produced when the ignition cone had a temperature of 500 to 600 deg. cent. (932 to 1112 deg. fahr.).

THE LATEST TYPES OF GAS PRODUCERS (*Die letzten Erscheinungen auf dem Gebiete der Gasgeneratoren*, Gwosdz. *Feuerungstechnik*, vol. 1, no. 9, p. 164, February 1, 1913. 4 pp., 8 figs. *d*). Quarterly account of the improvements in gas producer construction. The improvements noted are mainly in secondary details.

KERPELY REVOLVING GRATE GAS PRODUCERS (*Drehrostgeneratoren nach System Kerpely*, A. Gobiet. *Journal für Gasbeleuchtung*, vol. 55, no. 22, p. 1273, December 28, 1912. 6 pp., 7 figs. *de*). Description and some data of tests of the three standard German types of the Kerpely gas producer.

THE PROBLEM OF THE GAS TURBINE (*Le problème de la turbine à gas*, E. Grauce. *Revue de mécanique*, vol. 31, no. 6, p. 509, December 31,

1912. 15 pp., 9 figs. *t*). General discussion of the various gas turbine cycles and their relative efficiencies. The treatment is purely theoretical, no new experimental data being reported.

NOVELTIES IN THE FIELD OF DIESEL ENGINE CONSTRUCTION (*Neuerungen auf dem Gebiete des Diesel-Motorenbaus*, H. Al. Siebeck. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 3, p. 25, January 17, 1913. 3 pp., 11 figs. *d*). Description of the latest types of the Diesel engines, in particular those built by the Pauksch Co., Landsberg a.W., Germany, and their fuel pump and atomization devices.

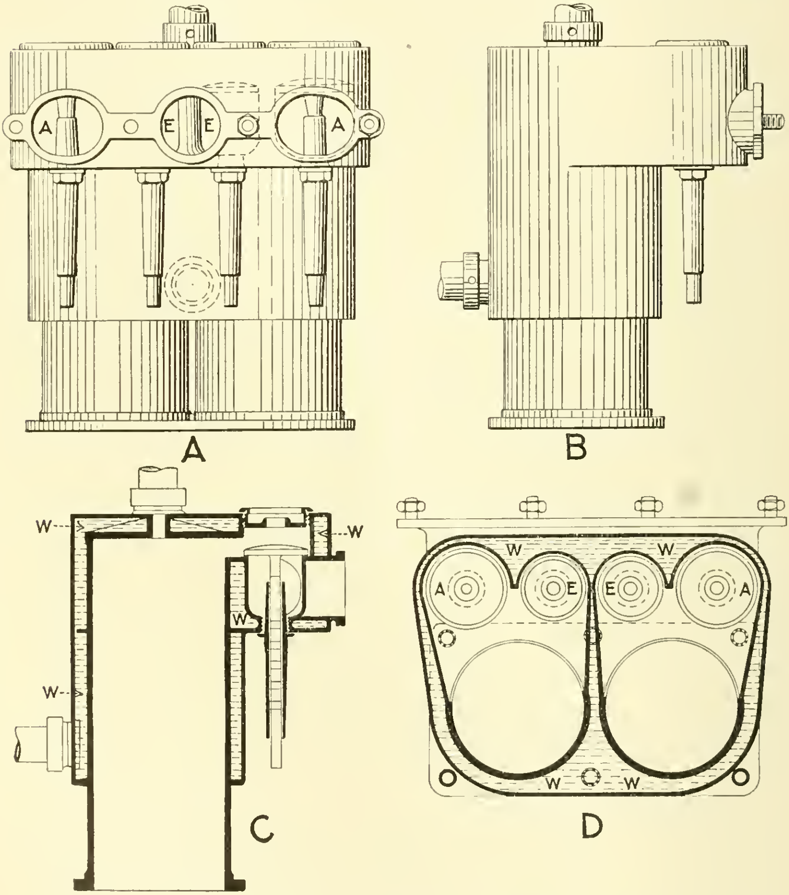


FIG. 4 AUTOGENOUSLY WELDED GAS ENGINE CYLINDERS

AUTOGENOUSLY WELDED STEEL CYLINDERS FOR EXPLOSION ENGINES (*Autogen geschweisste Stahlzylinder für Explosionsmotore. Autogene Metallbearbeitung*, appended to *Acetylen*, vol. 15, no. 23, p. 207, December 1, 1912. 3½ pp., 4 figs. *dp*). In the early days of the explosion engine industry an attempt was made to make the *cooling jacket of sheet metal*, and to solder it to the cylinder, but the soldering metal was different from that of the pieces united by it, and with the aid of the acid always present in the cylinders, an electric couple used to be created which led to the rapid destruction of the soldered joint. *Oxyacetylene welding* was found to give a much better method of *cylinder construction* in which only seamless piping and pressed mild steel sheet parts are used. Fig. 4 shows two and one cylinder sets of the Stahlmotoren-Gesellschaft Ernst Jaenisch & Co., of Berlin, Germany, which are said to have been tested on the stand and on an automobile for 1½ years and to have given fully satisfactory results. The advantages of these types of construction are supposed to be: the welded construction is easier to manufacture and more reliable in execution that an iron casting; the expansibility of mild steel is very much superior to that of cast iron, and the material more uniform, so that should even the water cooling fail for a time, there would be considerably less tendency for cracks to be formed: as shown in Fig. 4 C and D both the explosion and the valve chambers are entirely surrounded by cooling jackets which produces a better cooling than is possible in the case of a cast cylinder; the walls of the entire construction are of uniform thickness, and a thickness of 1.5 to 3 mm (0.06 to 0.118 in.) is sufficient for the mild steel plate of the cooling jacket; by this *a saving of about two-thirds in the weight of the cylinder is obtained*, a fact of material importance even for automobile construction, but tremendously more so for aeronautical engines (the article quotes a case of a reduction of the weight of the cylinder plant from 48 kg (106 lb.) for cast iron to 15 or 18 kg (33 or 39.7 lb.) for autogenously welded steel construction. Cast-iron construction involves a large outlay for patterns, with corresponding increases whenever new sizes are adopted, while with welded construction there is no need for patterns, and any sizes may be made by the same methods and appliances: experience has shown that thoroughly reliable work can be turned out under shop conditions, with all possibility of overheating the cylinder jackets being entirely eliminated. Each cylinder is submitted to a cold water pressure test at 100 atmospheres, and it is said that untight places are of rare occurrence even at this comparatively high pressure. It is further stated that while an appreciable percentage of cylinder castings is usually spoiled and goes to scrap, this is entirely eliminated with the new method of cylinder construction. The tests have shown that welded cylinders are also more efficient because the valve cross-section may be made comparatively larger owing to the walls being thinner, and because the mathematically correct distribution of passages and explosion chambers with respect to the piston permit a much higher compression.

New Gas Producer (*Novjy Gasogenerator*, *Dvigatel*, vol. 6, no. 24, p. 498, 1912. 1 p., 2 figs. *d*). Description of a *new gas producer* designed by a Russian engineer A. Simonenko. It is very much like the Rincker and Wolter producer described in *The Journal*, November 1912, p. 1881, with the difference, however, that it is intended to be used with peat as fuel, and the air and gases from the first shaft move in the second shaft upwards and not downwards as in the Dutch type. From the description of the

Simonenko gas producer it appears that there is no provision for alternating the direction of the flow of the gases between the shafts, as in the Rincker and Wolter, and the Berlin-Anhalt Company's types.

H. Pierper Gasoline-Electric Cars (*Automotrices pétroléo-électriques, système H. Pieper*, M. Hegelbacher. *Le Génie Civil*, vol. 62, no. 11, p. 201. 3 pp., 5 figs. *d*). Description of the Pieper *gasolene-electric car* used now on many suburban lines in Belgium and France. The motive plant consists of: (*a*) an explosion engine of average capacity corresponding to the average power required on the given line; (*b*) a direct-connected dynamo serving also as flywheel of the engine; it is shunt wound, and may act either as a generator or as a motor, at speeds varied by the field excitation; (*c*) a storage battery of 60 cells, divided into four sets, placed in pairs under the front and rear platforms of the car. When the car comes to a grade which the engine would be unable to handle, it is helped out by the storage battery; the battery is recharged by the dynamo acting as a generator on the downgrade sections of the run, the voltage adjustment between the two being regulated automatically. An interesting feature of this car is the *regulation of the admission of gas* to the engine *governed by a solenoid* with two windings inside of which moves a soft iron core acting on the gas admission organs. This regulator decreases or increases the gas admission according as the current passes into the battery or from it, so that on an upgrade the engine works at full admission, while on the downgrade the regulator closes automatically and admits just enough gas to allow the engine to overcome its passive resistances, the energy of the gravity driving the dynamo as a generator and charging the storage battery. Storage batteries are, however, expected to help the motor out only on comparatively moderate grades; when the run of the car includes steep and especially long upward grades, the engines must be made proportionally stronger, the principle of the system demanding that the *engine* furnish the *average* power required for the given run.

Mechanics

On the Calculation of Belt Transmissions (*Note sur le calcul des transmissions par courroies, Bulletin trimestriel de l'Association des Ingénieurs de l'Ecole Supérieure de Textiles*, no. 1, March 31, 1912 (?), p. 35, through *Le Mois scientifique et industriel*, vol. 14, p. 576, December, 1912. *p*). The most favorable speed is 20 to 25 m (65 to 82 ft.) per sec. for oak tanned belts, and 30 m (98 ft.) per sec. for chromium treated leather belts; the most convenient working tension 400 to 600 gr. per qmm (568 to 852 lb. per sq. in.). The section of the belt is given by the formula:

$$s = F\frac{ef\alpha}{ef\alpha - 1} \times \frac{1}{R - \frac{\delta v^2}{g}}$$

where F is the power transmitted; e the Naperian base; f coefficient of adherence; α arc of contact with the small pulley; R tension per unit, permitted; δ weight per unit of volume; v velocity per sec.; g acceleration for the unit adopted. The thickness of the belt should be from 1/20 to 1/30 of the radius of the pulley; for chromium treated pulleys, which are more elastic, 1/15 or even 1/12 may be permitted; a chromium treated leather belt, 10 mm (0.39 in.) thick has given good results on a pulley 120 mm (4.7 in.) radius. As to the axial distance, when the pulleys are of unequal diameter, it has to be selected so that $\frac{D-a}{2\delta} \geq 0.25$, where D is the diameter of the pulley; for pulleys of equal diameter, $\delta = 3D$ minimum. The life of a belt is inversely proportional to the coefficient of fatigue. This coefficient $f = K^{\frac{e+R}{R}} \times \frac{V_{,}}{\delta}$, where K is from 1 to 3, depending on the kind of machine and surrounding condition. (The article does not state the kind of units used in the equation: the usual continental units are probably used. The same notation for the coefficient of fatigue of the belt material and coefficient of adherence is used).

ON THE REALIZATION OF HIGH ANGULAR SPEEDS (*Étude sur la réalisation des grandes vitesses angulaires*, Maurice Leblanc. *La Lumière électrique*, vol. 20, nos. 51 and 52, pp. 355 and 387, December 21 and 28, 1912. And vol. 21, nos. 1 and 2, pp. 7 and 35, January 4 and 11, 1913. 27 pp., 32 figs. *mtA*). There are many cases in which it would be desirable to run wheels at great peripheral speeds, e.g. in large single-stage steam turbines which could be built in any size if their blades could be economically given the required speed. This cannot be done, however, by making the angular speed moderate and giving the wheel a large diameter, because the work absorbed by friction against the surrounding medium grows as the fifth power of the diameter, and only as the cube of the angular speed; in addition, a large wheel running at a peripheral speed of over 1,000 ft. per sec. is a dangerous piece of apparatus, and would have to be enclosed in a cage of which the weight grows rapidly with the diameter of the wheel. It is therefore of advantage, in order to obtain a large peripheral speed, to increase the angular speed rather than the diameter of the wheel. As to what a large single-stage turbine running at a high angular speed could drive, the author states that there are already such compressors, and that he has designed an alternator which would furnish current at commercial frequencies (15 to 50 cycles) when driven at considerably higher speeds.

The difficulty with machinery of usual construction running at high angular speeds is that the rotors and foundations must be of large mass and great rigidity in order to prevent the rise of vibrations; and even with that at starting and stopping, when the frequency of oscillations is apt to vary continuously, there is a great risk of falling into resonant oscillations which produce unforeseen fatigues both in the stator and rotor. Small machines running at high angular speeds and having rigid shafts and fixed brasses are heavier, in proportion to the power developed than larger machines rotating more slowly; also the friction at the bearings absorbs more power, and the efficiency is therefore lower. There are also other disadvantages, such as the nearly absolute impossibility to balance the rotor when it is partly formed of organic substances deformable in their

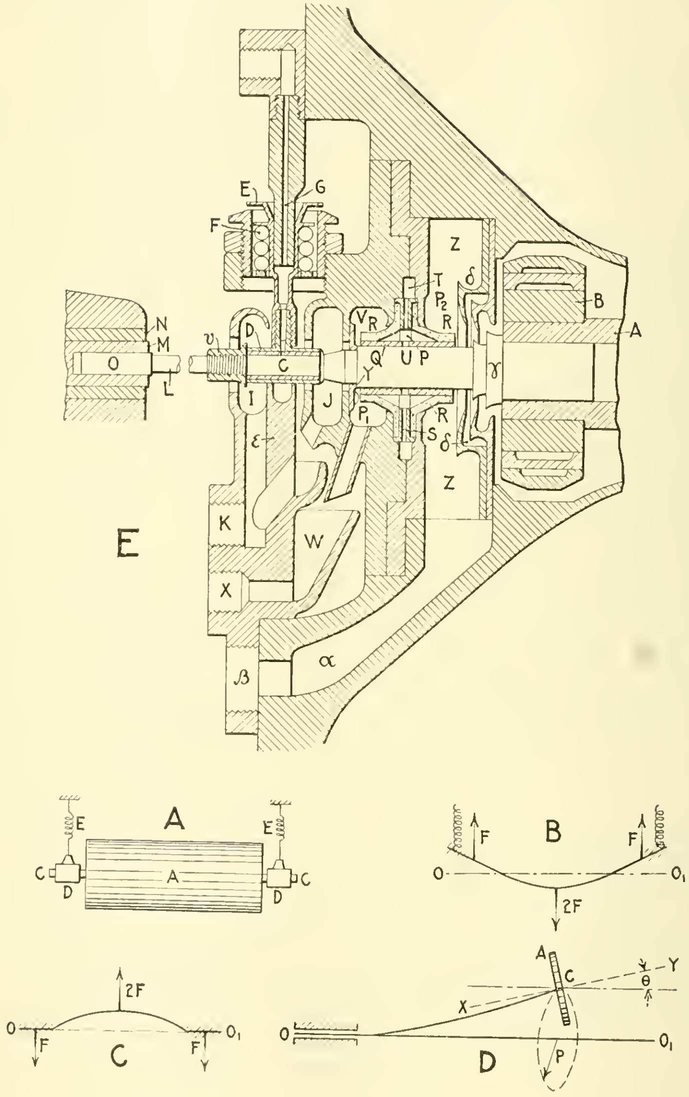


Fig. 5 Flexible Shaft and Joint Action

nature. *Most of these disadvantages disappear when the rotor is enabled to select at each instant its own axis of rotation just as a spinning top does on a perfectly smooth surface.* The problem is therefore, to support the rotor by elastic elements, while transmitting to it a couple if necessary, in such a manner that its real axis of rotation coincide as closely as possible with the axis of the figure of the stator; that would to a certain extent limit its freedom of motion, but forces acting in this way are very small in comparison with those which make it turn about its axis of the figure, and would not affect its output, while at the same time the bearings of the shaft could be made smaller and thus absorb less power in friction; the smaller the external forces limiting the freedom of motion of the axis, the less will be the amplitude of vibrations communicated to the stator, and such vibrations can be made entirely harmless (unless resonant oscillations arise, which ought to be carefully avoided). It is, however, clear that it is practically impossible to make a well balanced rotor rotating around the *axis of its figure* if it has a rigid shaft and fixed brasses, although this may be done when the rotor rotates about its *axis of inertia*, i.e., axis passing through or extremely near to the center of gravity of the rotor. To obtain smooth running at high angular speeds it is necessary to fulfil simultaneously *two* conditions: freedom of motion of the rotor and good balancing; fulfilling only one is not sufficient. With small rotors, i.e. exactly those where it is necessary, it is extremely difficult to obtain good balancing, but the author states that he has solved this problem by adapting automatic balancing devices to rotors free to select their own axis of rotation.

To do this in practice is comparatively simple when the driven apparatus is direct-connected because in that case there is only a single rotor and the shaft has to be supported only, but does not transmit any couple. If, however, no direct connection is used, then a couple is transmitted between a shaft with a fixed axis of rotation to that of a rotor which is free to select its own axis. Such a shaft has of course to be flexible. The author uses the term *flexible shaft* when it transmits a couple and supports the rotor at the same time, but calls it a *flexible joint* when the rotor is supported as shown in Fig. 5 A. In this latter case the rotor is provided with journals C lying on very light brasses D and in their turn supported on the two springs E: by varying their tension or bending, the rotor can move either horizontally or vertically. The journals must be as small and short as possible, and their dimensions are selected as if they had only the rotor to support; this allows the use of lighter bearings. Since there are springs, there is a fear of resonances arising at a critical speed, but, if the suspension springs are made very flexible, the critical speed may be made to be very low, and then there is no danger in clamping the bearings at starting until the critical speed is passed, and doing the same in stopping the engine. This is a simple way to eliminate resonant oscillations, and may be made entirely automatic.

The next danger is the deformation of the rotor. To prevent this it is necessary that the critical speed of the rotor itself, which corresponds to the mode of suspension and is different from the critical speed discussed in the preceding paragraph, be considerably above the maximum speed which it will have. A rotor in passing through its own critical speed becomes subject to dangerous deformations: its journals begin to jump causing fatigue to the bearings and springs, and it is liable to be ruptured. If the engine is a turbine driving a dynamo without a rheostat, the danger due to the critical speed may be avoided by giving the rotor a very large positive or negative acceleration in that neighborhood; this may be done by not exciting the field at starting, and leaving it excited in stopping. But when there is a rheostat there is considerable danger, and it is a good plan to limit the normal speed to about two-thirds of the first critical speed of the rotor proper. Since the rotor does not rest on fixed bearings, it cannot form an arch as shown in Fig. 5 C: the only way it can arch is by finding a fulcrum on itself, as shown in Fig. 5 B, but to produce that kind of deformation, a velocity considerably higher than that producing the deformation of Fig. 5 C is necessary, and in practice a rotor can nearly always be designed to keep well below that limit. Since further in geometrically similar rotors made of the same materials, the critical velocities of the rotors proper are inversely proportional to their linear dimensions, it follows that as the linear dimensions of the rotors decrease, higher angular velocities may be communicated to them with the same degree of safety, just as required in this case. *The absolute magnitude of the angular velocity has no importance whatever so long as it is below the critical velocity of the rotor proper.*

Theory of the Flexible Shaft. Let OO' be the axis of the brasses O (Fig. 5 D) and also the axis of rotation. The flexible shaft carries a rotor A having its center of the figure C located on its neutral axis. The axis of the figure xy of the rotor is tangent to its neutral axis at C. The angle θ is by supposition so small that $\sin \theta = \theta$ and $\cos \theta = 1$.

The author shows that if under these conditions a rotation is communicated to the deformed flexible shaft at a speed ω about a fixed axis OO', and if it is further given a speed of precession α, about that axis, the rotor on the shaft will rotate at a speed $\omega - \alpha$ with respect to the neutral axis of the shaft. A flexible shaft permits therefore of transforming a movement of pure rotation about the axis OO' at speed ω into a movement of rotation of speed $\omega - \alpha$ about an axis xy, and a movement of precession of speed α referred to the axis xy. This reduces both the bending effort on the shaft acting when its axis does not coincide with the axis OO' and the stresses on the brasses which support it, since these stresses depend now not on the speed ω, but on α. This also produces some gyroscopic phenomena which in their turn tend to increase the stability of operation.

Flexible Joint. The author investigates in detail the conditions regulating the selection of a flexible shaft or flexible joint, the latter having the advantage of not being deformed by the weight of the rotor or by clamping the brasses at a time when the system passes through its critical velocity. Fig. 5 E shows the design of the flexible joint which the author adopted after considerable experimentation. The rotor A provided with automatic balancers (one of them can be seen at B) ends in two journals, short and of small diameter, one of which is shown at C. Each of the journals rests on a brass D as light as possible and supported by a suspension piece *E* which is in aluminum and rests on rubber washers *F*. Lubricating oil is brought to *E* by the pipe *G*, and passes further to the center of the brass by the hole *H*. On the surface of the brass two helicoidal grooves are cut, one to the right and the other to the left, starting from *H* to the interior. The oil is carried away by the rotation of the journal, and provides for its lubrication no matter what position may be taken by the journal.

In the last section of his article the author discusses a system of automatic balancing by means of two hollow tores filled with mercury. In view of the interest and comparative novelty of this device, a more complete description will be given in an early issue of *The Journal*.

Pumps (See Also Air Machinery)

Action and Design of Air Vessels in Plunger Pumps (*Wirkungsweise und Berechnung der Windkessel von Kolbenpumpen*, Gramberg, *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 129, 1912. 62 pp., 34 figs. *etA*). The author has found experimentally that resonance phenomena may take place in the piping of plunger pumps when the natural frequency of the water column acted on by the pressure of the air vessel is in a suitable ratio (expressed by integral numbers) to the speed of rotation of the engine. These resonance phenomena produce large extra pressures and may therefore be quite dangerous; in addition they consume extra power, in some cases as much as 35 per cent. The usual statico-volumetric theory of the air vessel is therefore declared to be unsatisfactory. The author insists that the dimensions of the air vessel be a function of the speed of rotation, delivery pressure, and size of pressure piping, but independent of the lift space; he derives several equations in accordance with these principles. When several pumps work with several air vessels, all cases of possible resonance must be foreseen, and provided against by giving the air vessels proper dimensions.

Drouville Multicylinder Fire Automobile Pumps (*Pompe à incendie multicylindrique système Drouville*, D. Duaner. *Le Génie Civil*, vol. 62, no. 14, p. 271, February 1, 1913, 2 pp., 5 figs. *d*). Description of the Greindl two-axis rotary pump and Drouville multicylinder pump. The Greindl pump has an arrangement somewhat similar to that of the Root blower, while the Drouville pump has four crosswise disposed single-acting cylinders, the four pistons acting successively in the order of rotation, and thus producing a constant flow of water in the same direction. This arrangement permits of reducing the clearance spaces, while a supplementary arrangement of the pump body in the form of two annular and concentric chambers eliminates the possibility of eddies and water hammering.

The Neumann Involute Pump and its Properties (*Die Evolventenpumpe "System Neumann" und ihre Eigenschaften. Der praktischer Maschinen-Konstrukteur*, vol. 46, no. 2, section "Pumps," p. 2, January 16, 1913. 2 pp. 11 figs. *d*). In *The Journal*, August, 1912, p. 1254, reference was made to a new principle of pump construction. The following is an abstract of what is claimed to be the first published statement of what this principle is. It is claimed that in this pump the water is conducted in the passages between blades in such a way that the velocity-pressure conversion is nearly perfect. The vertical section of the blade wheel profile is said to be usually limited by two bodies of revolution; equal blade heights are therefore on concentric circles, and the individual sections *a-a*, *b-b*, etc. (Fig. 6, A) are therefore trapezoidal, which in itself indicates a poor design of the passage between the blades. This was further proved by tests (not stated where made) of a centrifugal pump wheel similar to that of the pump used for driving the illuminated fountains at the Nuremberg Exhibition in 1906. In that pump there were two wheels each of which had to deliver 6.5 cbm (230 cu. ft.) per min. at a height of 50 m (164 ft.). By calculation the entrance velocity in the runner passages at *a* was found to be 16 m (54 ft.), the outlet velocity at *c* 7.8 m (25.6 ft.) The velocity fall from 16 m to 7.8 m had to produce a pressure head of $(16^2 - 7.8^2) : 2g$, or about 10 m (32.8 ft.). As shown by the dotted curve in Fig. 6, B, where the ordinates are the average velocities at different cross-sections, and the abscissae the respective cross-sections, there is a very rapid velocity fall from *a* to *c*; from *c* on the deceleration is much slower, and in *d* the velocity reaches its minimum of about 6.8 m (22.3 ft.), the velocity rising to about 7.8 m (25.6 ft.) at the outlet.

Such a shape of the characteristic curve, with its uneven deceleration and acceleration, is of course not favorable to the production of the most efficient velocity-pressure conversion, which results in shocks, in their turn reducing the regular action and efficiency of the pump. All these defects are said to be eliminated in the new wheel shown in Fig. 6, C. All the runner passages have exactly rectangular cross-sections so proportioned that the velocity curve is a straight line (the full line in Fig. 6, B), the most conducive to perfect velocity-pressure conversion. Fig. 6, D shows the profile of such a runner. The upper limiting line is still part of a body of revolution, but the lower is not; further, equal passage heights are to be found not along concentric circles, as hitherto, but in equal cross-sections normal to the direction of the flow of water, the blade passage produced being as shown schematically in projection in Fig. 6, E: all the cross-sections are rectangles, with areas steadily increasing up to the outlet, the passage between the blades having really the form of a conical tube with rectangular cross-section.

Improvements in the rim clearance arrangement is also claimed. The usual arrangement is such that the water flowing with great velocity from the rim strikes normally the water flowing through the suction pipe which produces strong eddies, noise and loss of efficiency. In the arrangement shown in Fig. 6, F the water coming out from the rim is deflected so as to flow in the same direction as the water flowing in the suction pipe which not only eliminates the eddies, but helps to recover part of the energy stored up in the water coming from the rim: this water acts in the suction pipe somewhat as an ejector, and permits the use of a shorter suction pipe. Fig. 6, G, taken from *der praktische Maschinen-Konstruktieur*, vol. 45, no. 12, shows a 12-stage, high-pressure involute pump built by the Armaturen- und Maschinenfahrik- A-G. vorm J. A. Hilpert in Nuremberg, or rather one-half of it having 6 of the 12 stages, this part of the pump designed to deliver 3.3 cbm (116 cu. ft.) per min. 260 m (852 ft.) high. Its efficiency is said to be 78 per cent.

High-Pressure Centrifugal Pumps used for Fire Engine Work (*Pompes centrifuges à haute pression employées comme pompes à incendie, Bulletin technique de la Suisse Romande*, vol. 39, no. 1, p.l. January 10, 1913. 7 pp., 12 figs. *de*). Description and data of tests of the Sulzer type centrifugal fire engine pumps and Sulzer motor driven fire engine.

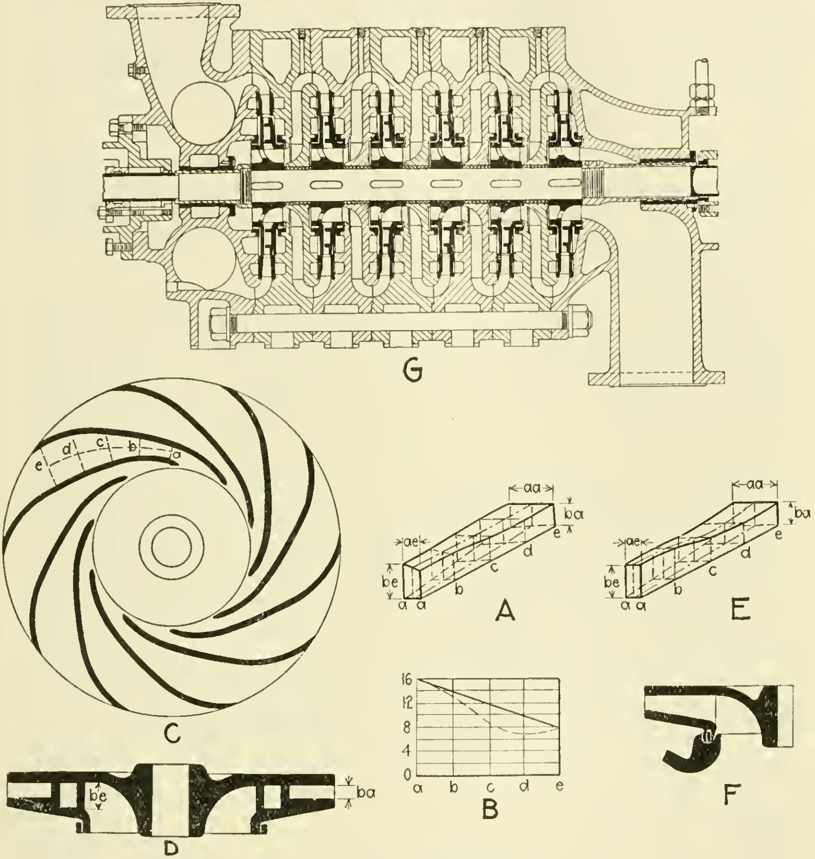


Fig. 6 Involute Water Pump

Steam Engineering

Regulation of Hot Steam Temperatures (*Die Regelung der Heissdampf temperaturen*, Generlich. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 48, p. 1946. 2½ pp., 3 figs. *de*). *The temperature of superheated steam* is a function of many factors not easily controlled, and all attempts to regulate it by flaps, mixing valves, etc., are connected with certain difficulties of operation. The German Babcock & Wilcox Co. has patented a new type of superheater in which first the entire steam generated by the boiler is superheated, and then, by means of a patent three-way mixing valve, the steam is taken either direct from the superheater, or first led through a ribbed pipe lying in the water space of the boiler, where it gives up part of its heat to the cooling water. This steam of lower temperature may then be added to the superheated steam coming direct from the superheater. The temperature may be varied within a range of 80 to 175 deg. cent. (144 to 315 deg. fahr.). The advantages of the new superheater type are said to be: full utilization of the superheater surface, absence of superheater flaps, and better regulation of temperature than is possible with an ordinary mixing valve.

SIMULTANEOUS PRODUCTION OF ELECTRIC ENERGY AND HEAT (*Production simultanée d'énergie électrique et de chaleur*, A. Beaurienne. *Mémoires de la Société des Ingénieurs Civils de France*, ser. 7, vol. 65, no. 11, p. 701, November, 1912. 40 pp., 24 pp. *dg*). A compendium on the utilization of heat as a by-product of steam motive plants.

UTILIZATION OF LOW-COST FUELS AT THE MINES OF THE DORTMUND MINING DISTRICT (*Ausnutzung minderwertiger Brennstoffe auf Zechen des Oberbergamtsbezirks Dortmund*, Bütow and Dobblestein. *Glükauf*, vol. 48, no. 52, p. 2101, December 28, 1912. 3 pp, 3 figs. *e*). Data of tests with *coke breeze as fuel* at the new plant of the Minister Achenbach mine in Brambauer, Germany. The plant consists of four double-blue boilers, 96.4 qm (say 1070 sq. ft.) heating surface each. The boiler under test was fitted out with a Wilton closed ashpit furnace, with a grate area 2.47 qm (26.5 sq. ft.), and a consequent ratio of grate area to heating surface as 1:39; the boiler was previously in operation for several weeks. The steam blower consumed the first day 74.3, and the second 86.5 kg (166 and 192 lb.) of steam per hour. With a chimney draft of 5.3 mm (0.21 in.) of water, an average of 15 kg of steam per qm (3.08 lb. per sq. ft.) of heating surface was generated, and the tests have demonstrated on the whole that even with a poor draft, a closed ashpit furnace permits of burning coke breeze economically. With the cost of fuel taken at M2.18 per ton (say $0.48 per short ton), and the price of a Wilton furnace for a double-flue boiler at M1000 (say $385.00), the cost of steam was about M0.85 per ton (say $0.185 per short ton). The iron chimney, 22.8 m (say 75 ft.) high was later replaced by another, 60 m (196 ft.) high, and tests were made to determine the comparative losses of a Wilton and a horizontal grate furnace; it was found that with the first an economy of about 15 per cent was obtained. The article contains full data of the tests.

DEVELOPMENTS IN THE GERMAN SECTIONAL BOILER INDUSTRY (*Neue Wege der deutschen Gliederkesselindustrie*, Pradel. *Zeits, für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 1, p. 1, January 3, 1913, 8 pp., 33 figs. *dh*). Description of various new German types of cast-iron *sectional boilers* for heating purposes, with a short historical sketch of the development of the various types. Interesting as a compendium of the German heating boiler practice; no new types are described.

THE IMPORTANCE OF HOLLOW WATER COOLED GRATES FOR THE INDUSTRY GENERALLY AND FOR NAVIGATION (*Die Bedeutung des wassergekühlten Hohlrostes für die gesamte Industrie und Schiffahrt*, H. Dinkgreve. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 1, p. 4, January 3, 1913.

4 pp., 4 figs. *dg*). From a paper read before the Hannover Section of the Verein deutscher Ingenieure, November 29, 1912. A brief description of the types of *hollow water cooled grates* and detailed discussion of their advantages. In the Grabowsky construction a double header is used and the grate bars are welded in, the bars, however, having freedom enough to expand with heat. The water used for grate-bar cooling is returned to the feedwater tank in land boilers; in marine boiler practice sea water is used for cooling, and returned overhead. The article quotes the following test data:

No. of test	1	2	3
Water evaporated, kg/lb	30200/66440	33305/73271	4206/9253
Cooling water, kg/lb	25756/56663	23855/52481	5319/11702
Actual gain in temperature, cent./fahr	33.4/60.3	37.7/67.5	19.1/34.4
Gain in temperature, reduced to feedwater, deg. cent./fahr	28.6/51.3	27.0/48.6	24.0/43.2

In this table tests 1 and 2 were made by the Hamburg Association for Smoke Prevention, and 3 by the Hannover Association for the Inspection of Steam Boilers. As regards the amount of coal burned per unit area, which in the case of marine boilers may be quite large, the sections of the bars and their inside cooling is proportioned so that the bars, even when 2.5 m (8.20 ft.) long may have sufficient cooling to admit loads from 300 kg. per qm-hr. (61 lb. per sq. ft. per hr.) of grate area, without affecting in the least the life of the grate bars. A further advantage of the hollow grate bars is the smaller amount of cleaning and clinkering. During the above quoted tests at Hanover it was found that while the solid cast-iron grate had to be cleaned five times during the 7.12 hr. of the test with an expenditure of 10 to 15 minutes each time; during the 6.13 hr. of the tests of the hollow water-cooled grate bars, only one cleaning near the end of the test was required which took less than 5 minutes. The water-cooled grate bar is also more efficient thermally, since it takes up nearly all the radiation directed downwards and permits the heat to be taken up by the cooling water; in the case of solid grate bars only part of this heat is utilized for preheating the air. The average saving in fuel due to all causes was found to be on the average about 5 per cent.

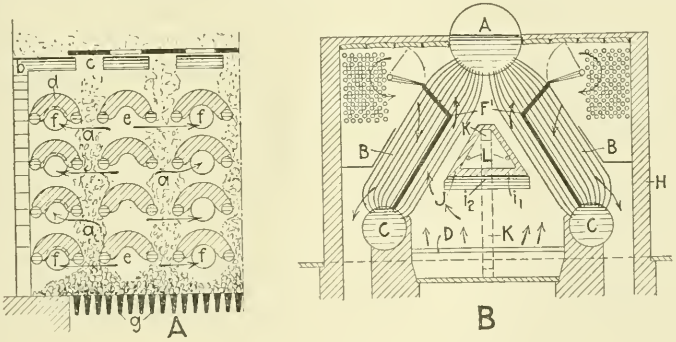


Fig. 7 Pamart and Krupp Furnaces

It is further stated that the absence of clinker on the grate due partly to the absence of frequent cleaning of the fire and consequent cooling of the fuel bed helps to produce a practically smokeless combustion. As far as the efficiency of the boiler is concerned, however, perhaps of most importance is the simplicity of taking care of the firing with hollow water-cooled grate bars permitted by the use of very long grates, up to 2.5 m (8.20 ft.) which, together with other things, is said to raise the efficiency of the boiler installation from 30 to 50 per cent. The German Navy ordered installed for testing purposes, a hollow water-cooled grate on its latest cruiser "Blücher."

Novel Features in Solid Fuel Furnace Plants (*Neuerungen bei Feuerungsanlagen für feste Brennstoffe*, Pradel. *Feuerungstechnik*, vol. 1, no. 8, p. 147, January 15, 1913. 3 pp., 10 figs. *d*). Quarterly account of the novelties in *furnace types*. In the furnace of E. L. Pamart, of Paris, France (Fig. 7 A), the furnace walls *b* are filled with water. The fuel (very small coal or even coal powder), is charged through the openings *c* provided with regulating slide valves. The furnace proper is divided gridwork-wise by the little bridges *d* supported on water filled pipes connected with the water jacket of the furnace. The bridges are staggered, and the fuel, before falling upon the grate, piles up on them for a short time. The spaces are limited by two small bridges *d* from above and below and by the piles of fuels on the sides, and are connected in alternate rows either with air admission openings *e* in the front wall, or with the air outlet openings *f* on the rear wall, so that the air travels in the direction of the arrows, and forces its way through the fuel piles.

Fig. B shows a water tube boiler built by the Germaniawerft of the Krupp Company. Its peculiarity consists in that an air preheating set *j* is built in above the grate between the tubes of the boiler. It is made of fire proof material, runs from the front wall to the rear; the lower wall i^1 is built like a supporting arch, while the side walls run parallel to the longitudinal direction of the tube nests. The preheated air is conducted below the grate by the pipe *k*. The preheating element is proportioned so that there is plenty of room for the gases to flow around it to the boiler tubes, and enough space below it for proper combustion.

Strength of Materials and Materials of Engineering

Contributions from the Royal Testing Laboratory at Gross-Lichterfelde West (*Mitteilungen aus dem Königlichen Materialprüfungsamt zu Gross-Lichterfelde West*, vol. 30, no. 4, 1912):

(*a*) Influence of Time-Rate of Increase of Load in Compression Tests of Cement Cubes on the Results of the Tests (*Einfluss der Belastungsgeschwindigkeit bei Druckversuchen mit Zementwürfeln auf das Prüfungsergebniss*, H. Burcharz, p. 181. The tests have shown that the results of tests are influenced by the speed with which the load increases: the faster the load increases, the more favorable seem to be the results; the higher appears to be the rupturing load. An Amsler-Laffon press with a mercury column was used in these tests.

(*b*) Accelerated Tests for Constancy of Volume of Portland Cements (*Beschleunigte Prüfung der Raumbeständigkeit von Portlandzemen-*

ten, Professor M. Gary, p. 196). Full publication of the paper presented by the author at the Sixth Congress of the International Association for Testing Materials (XIV 2, no. 9).

(*c*) CONTRIBUTIONS TO THE TESTING OF BALLOON MATERIALS (*Beiträge zur Prüfung von Ballonstoffen*, K. Memmler, p. 202, 10 pp., 5 figs.). Description and data of tests of the *bursting strength of balloon materials*. The Gradenwitz apparatus for testing balloon materials had the disadvantage of using large pieces of material (570 mm., or 21 in. in diameter) which made the test expensive, and when such large pieces could not be obtained, impossible. The new apparatus designed by Professor Martens and fully described in the original article can test pieces of 0.01 to 0.3 qm (0.1 to 3.2 sq. ft.) area, and can handle elliptical, triangular, and other shapes just as well as circular pieces. The apparatus consists essentially of two flasks of compressed air supplied to the lower side of the cloth under test which is held by metal rings against a rubber basis. The arching of the cloth is recorded on a paper drum which rotates proportionally either to the time elapsed, or to the air pressure producing the arching; two manometers are used: one to show the air pressure applied to the cloth under test, the other that in the air flasks. The test gives two series of data: bursting pressure p and height of arching h. For the determination of the bursting strength of the cloth the formula given in Moedebeck's Pocketbook has been used, and it was found that the bursting strength of the material as determined by means of this formula decreases with the increase of the radius of the piece under test. It was also found that the tearing strength (Zerreissfestigkeit, stress in the direction of each thread) of the material under the test conditions amounted to only about 60 to 70 per cent of the bursting strength (Zerplatzfestigkeit). It was further found that the humidity in the air has a material bearing on the data of tests.

(*d*) TESTING OF PLASTIC MORTARS (*Prüfung plastischer Mörtel*, M. Gary, p. 214, 10 pp., 9 figs.). Preliminary publication of part of the data presented by the author at the Sixth Congress of the International Association for Testing Materials (XIII 2, no. 9).

DRILLING TEST FOR THE DETERMINATION OF THE HARDNESS AND MACHINING QUALITIES OF METALS (*Der Bohrversuch zur Bestimmung der Härte und Bearbeitungsfähigkeit von Metallen. O. Bechstein. Prometheus*, vol. 24, no. 1210, p. 217, January 4, 1913. 2 pp., 3 figs. *de*). As early as 1899 Mr. W. Keep pointed out that hardness and machinability of a metal may be determined by drilling, since in a given time, with a given power applied and speed of rotation used, the depths of drilled holes are proportional to the hardness or machinability of the respective materials. Alfred H. Schütte, of Cologne, Germany, have placed on the market an attachment (Fig. 8 A) which may be placed on any drilling machine, in which the rotation of the drilling spindle is transmitted to a small screw spindle; on the latter, in accordance with the rotation of the spindle, a nut moves upwards, guided by two lateral guide rods and carrying a pencil pressed by a little spring against a paper covered drum, the ratio of transmission being usually so selected that a vertical displacement of 1 mm (0.039 in.)

of the pencil point on the indicator drum corresponds to two revolutions of the drilling spindle. On the journal which usually carries a hand wheel for feeding the drilling spindle, is placed a balance lever consisting of two quadrants, a small one on the left, and a large one on the right, with a weight attached to drive the indicator drum at a uniform speed. During the test, the vertical motion of the pencil point along the paper of the drum due to the rotation of the drilling spindle is deflected by the feed of the spindle which is a function of the depth of the drilled hole, and the line made by the pencil on the drum is an inclined one, as shown in Fig. 8 B, where the speed of the drill is used as ordinates, and the drill hole depths as abscissae. When the material is homogeneous, the line is straight; otherwise it is curved. This device is of interest for it appears to be cheap enough to be used even in small machine shops, and it gives simultaneously and in a short time indications as to the properties of materials sufficient for most practical purposes.

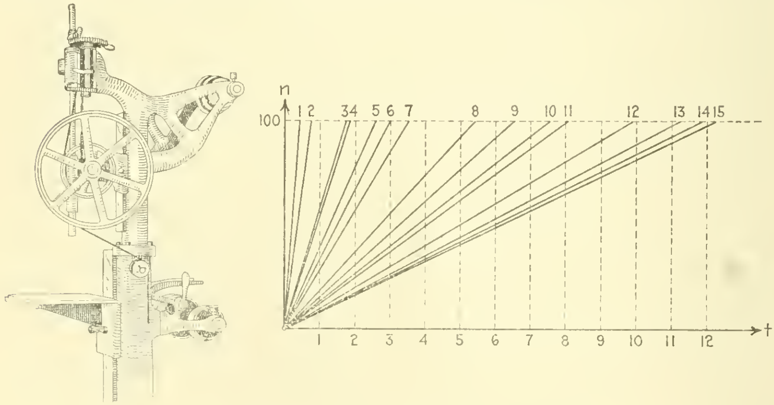


FIG. 8 HARDNESS DETERMINATION BY DRILLING

HOW TO RECOGNIZE GOOD LUBRICATING OILS (*Wie erkennt man gute Schmieröle?* F. Gelbig. *Braunkohle*, vol. 11, no. 41, p. 657, January 10, 1913, 2 pp. *p*). Practical directions for *determining roughly the qualities of lubricating oils* without the use of special testing apparatus. To detect the presence of solid impurities in the oil, to half a tumbler of oil kerosene is added until the whole becomes quite thin. The mixture is then filtered through filter paper or ordinary white blotting paper, and after all the oil has passed through, the paper is washed with kerosene; the residue on the paper, if any, will show if the oil had any solid impurities. Impurities may also be roughly detected by smearing a piece of writing paper with oil and holding it against light; if the oil is free from solid impurities, the blot will be equally transparent throughout; otherwise, the solid particles will show. The oil must not resinify: to test it in this respect, it is enough to pour it into a shallow dish and leave in a warm place about a week: there must not be the slightest crust at the end of that time. Another way to test it is by mixing it with fuming nitric acid: if the oil is pure, a thick mass will form in a few hours, while resinifying oil will remain thin. Acids are very injurious impurities in lubricating oil acids since in time they attack the machine parts lubricated. To test for them, copper oxydul or copper ash is added to the oil in a glass vessel: acid-free oil retains its original color, while, if it contains acid, it becomes greenish or bluish. Another test is to drop the oil on a sheet of copper or brass and leave it so far a week; if the oil contained acid, there will be a green spot on the metal. Blue litmus paper dipped in acid-free oil stays blue, but becomes red if the oil contains acid. A good oil must be greasy and sticky: to find which of several oils is best in this respect, place a few drops of the different oils on a smooth, slightly inclined metal or glass sheet; the drop of the stickiest oil will travel furthest in a given time. The article describes also methods for testing oils for viscosity and flash-point, but this part is omitted because the tests described require apparatus not usually available in the engine room, and unless done with proper care and appliances present in some cases considerable danger.

PROCESSES OF TREATING WOOD WITH CHEMICALS IN ORDER TO PRODUCE MATERIALS STABLE WITH RESPECT TO VARIOUS INFLUENCES (*Die Verfahren zur Behandlung des Holzes mit Chemikalien zum Zwecke gegen die verschiedensten Einflusse beständige Produkte zu erzeugen*, S. Halen. *Kunststoffe*, vol. 2, nos. 22 to 24, pp. 424, 449, 461, November 15. December 1 and 15, 1912. 15 pp. *d*). List of patents, foreign and American, with brief statement as to the process patented, on the *treatment of wood* by various preservatives. Several hundred patents are quoted.

SAFETY OF "HIGHLY STRONG" WINDING ROPES (*Sicherheit hochfester Förderseile*, D. F. Baumann. *Glückauf*, vol. 49, no. 4, p. 117, January 25, 1913, 3½ pp. *e*). The article is written mainly on the basis of the data obtained in the experiments of Speer with a view to determine the principles to be used in installation of *winding ropes of very strong materials.* The author concludes that the number of safe bendings of a rope increases with the increase of the breaking strength of its wires (a fear was expressed that ropes made of very strong material in fracture would prove weak in bending); rapidly increases with the increase in the radius of curvature; and slowly decreases with the increase of load. It is therefore advisable to select ropes of high strength for great depths and large loads; it is not absolutely necessary to use larger pulleys for very strong ropes.

Thermodynamics

SPECIFIC HEATS AND SPECIFIC VOLUMES OF STEAM FOR PRESSURES UP TO 20 ATMOSPHERES AND TEMPERATURES UP TO 550 DEG. CENT. (*Die spezifische Wärme und das spezifische Volumen des Wasserdampfes für Drücke bis 20 at und Temperaturen bis 550° C.*, Max Jakob. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 49, p. 1980, December 7, 1912. 8 pp., 3 figs. *etA*). The author starts with Clausius thermodynamic relation determining the relation between c_p and v, and shows that the determination by its means of c_p as a function of v is extremely difficult, since it depends on the curvature of the isobars in the vT diagram, which is, however, very slight and can scarcely be determined exactly; as a result, equations which have v correct to tenths of 1 per cent, may lead to values of c_p being several per cent wrong. On the other hand, v may be determined from c_p fairly correctly. From the Clausius relation, by double integration in T, is obtained:

$$v=\Phi(p)+T\Psi(p)-\frac{1}{A}\int\int\frac{1}{T}\frac{\partial c_p}{\partial p}dT_2\ldots\ldots\ldots\ldots\ldots\ldots[1]$$

If the legitimate assumption is made that the steam is in the state of an ideal gas when $\frac{\partial c_p}{\partial p}=0$, and as the initial point of integration is selected the temperature T_o corresponding to $\frac{\partial c_p}{\partial p}=0$, then:

$$v=\frac{BT}{p}-R=\frac{BT}{p}-\frac{1}{A}\int_{To}^{T}\int_{To}^{T}\frac{1}{T}\frac{\partial c_p}{\partial p}dT^2\ldots\ldots\ldots\ldots\ldots\ldots[2]$$

This requires only double integration of a simple differential quotient, and integration of imperfectly known functions not only does not introduce material errors, but often eliminates some imperfections of the function. If therefore $\frac{\partial c_p}{\partial p}$ contained errors as high as 10, or even 20 per cent, which with our present knowledge is possible even in the case of the best determined values of c_p, that would materially affect only the member R, while the value of v would be hardly out more than a few tenths of 1 per cent. When therefore H. N. Davis called the reconciliation of the accepted volume and specific heat measurements in the superheated region "the most important of the outstanding problems in the field," he had in view the passage from v to c_p, and not vice versa, which is the object of the present article. To do this the author uses a graphical method stating that any formula that he might derive would be so complicated and involve such integrations as to be inapplicable in practice, and would have to be simplified to make them applicable, while graphical methods require no such adaptations; further, after the chart is made, they may be used with as much convenience as formulae.

For these tests values of c_p for pressures up to 20 atmospheres, and temperatures up to 550 deg. cent. were used from the experiments of Knoblauch-Jakob-Hilde-Mollier, as well as the data of the experiments of H. N. Davis. In Fig. 9 *A* the isobars are plotted on a c_pt diagram in steps of 2 atmospheres for pressures from 0 to 20 atmospheres, the isobar for 1 atmosphere pressure being plotted as a dotted line. Each isobar extends from the saturation limit to 550 deg. cent., the line on the left representing the saturation curve (the original article has tables containing the values from which this and the other curves were plotted). The isobars for 2, 4, 6, and 8 atmospheres according to the Knoblauch-Jakob-Mollier experiments are here plotted anew, and differ but little from those published by Knoblauch-Hilde-Mollier, the difference in c_p only in one case exceeding 0.5 per cent (at the saturation point of the 2 atmosphere curve). The curve for $c_{po}=\phi\ (T)$ was determined both from the Davis equation and from the values of c_p for 2 to 8 atmospheres; the value for 1 atmosphere was found by interpolation.

Tests are now being made at the Laboratory for Technical Physics of the

Munich Technical High School to determine the isobars for pressures from 10 to 20 atmospheres (those of Knoblauch and Jakob were found by interpolation). The isobars in Fig. 9A were derived from the curve for c_{po} on one hand and the Davis

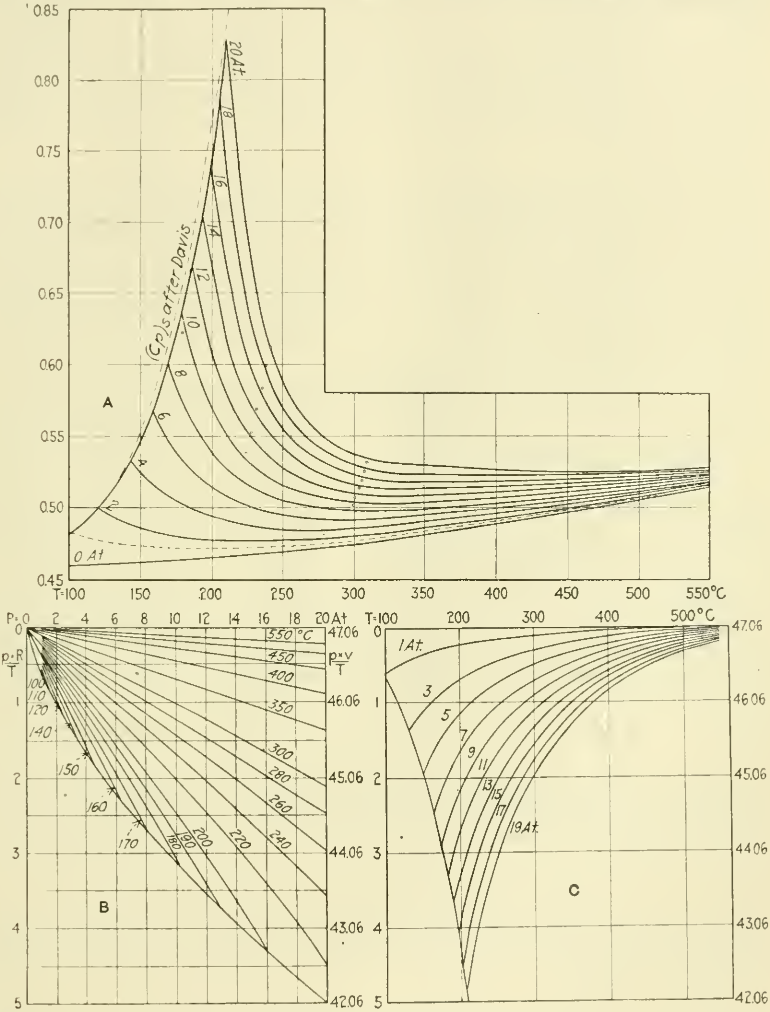


Fig. 9 Jakob Charts for the Determination of Specific Heats and Specific Volumes of Steam

values of $\frac{c_p}{c_{po}}$ at pressures of 10, 12, 14, 16, 18, and 20 atmospheres; the precise values so derived have been plotted as little circles. For the saturation curve the author proposes the equation

$$(c_p)_s = 0.455 + 2.10^{-20} \frac{T_s^8}{T_k - T_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

instead of the Knoblauch and Jakob which failed for pressures below 2 atmospheres. The new equation gives exact values for saturation points at 2, 4, 6 and 8 atmospheres, and provides further that $(c_p)_s$ becomes infinitely large at the critical temperature $T_s = T_k$, as required by thermodynamics. It holds good down to very small pressures, as the author shows by examples. It is of interest to note that the new Jakob equation coincides very well with the Davis values of $(c_p)_s$: the variation between the Davis saturation curve in Fig. 9A and the Jakob curve is less than that between the Davis curve and the points from which it was derived.

The author calculates, on the basis of the Davis equation for r, the values for the heat contents i, and thereby proves that his c_p system satisfies the condition imposed by Knoblauch-Hilde-Mollier, viz., that at constant temperature to the increase of c_p with the pressure corresponds a simultaneous decrease of the heat contents. The decrease of i with increase of pressure is irregular, owing to the decreasing exactness of the values of i, and an extension of the isobars to correspond with higher temperature would give a point of intersection at 920 deg. cent., where i would be equal for all pressures.

The author explains further, though he does not show it, how from Fig. 9A he obtained graphically the values for R and v in equation [2]. From the system of isobars of Fig. —A was derived a system of $\left(\frac{\partial c_p}{\partial p}\right)_p = g(t)$ isobars by dividing the difference $(\Delta c_p)_T$ between each two contiguous isobars by their pressure difference $\Delta p = 20{,}000$ kg. per qm.; from this the second derived system of $\left(\frac{1}{AT}\frac{\partial c_p}{\partial p}\right)\Big| = h(t)$ was obtained by dividing the first by $\frac{1}{AT}$. Each of the curves of these latter isobars was next integrated by means of a planimeter from the common point of intersection $t_o = 920$ deg. cent., or $T_o = 1200$ deg. abs., to different temperatures between T_c and the saturation temperature T_s, which gave a new series of isobar values $\int_{To}^{T} \frac{1}{AT}\frac{\partial c_p}{\partial p}\,dT = j(t)$; after these values had been integrated in a similar manner by means of a planimeter, a series of values for R were obtained (the author gives them in a table), from which the values of v had been derived by substituting for B the value of the gas constant for steam, or 47.06 (a table of v values is also given). The values of $\frac{pR}{T}$ with R derived as described above are plotted in Fig. 9B as isotherms, and in Fig. 10C as isobars.

General Form of an Equation of State. Linde and others have tried to establish an equation of the form

$$\frac{pv}{T} = B - F(p)G(T) \dots\dots\dots\dots\dots\dots\dots\dots [4]$$

In the author's estimation Fig. 9B and C take the place of such an equation, where Fig. 10B shows in addition that $F(p)$ is developed as a function of increasing exponents of p, and $G(T)$ of those of $\frac{1}{T}$. The complete solution of this equation by means of these curves, though possible with approximate correctness, would be of value only if the double differentiation in v and T of the Clausius relation would give values of c_p agreeing with those accepted at the beginning of

TABLE 1 SPECIFIC VOLUMES ACCORDING TO JAKOB (v_J) AND LINDE (v_L)

P in atmospheres, deg.		1	3	5	7	9	11	13	15	17	19
$t = t_s$	v_J	1.7281	0.6182	0.3826	0.2785	0.2195	0.1813	0.1546	0.1346	0.1193	0.1071
	v_L	1.7260	0.6173	0.3820	0.2782	0.2190	0.1810	0.1543	0.1344	0.1190	0.1068
$t = 130$	v_J	1.8789	......	......	......	......	......	......	......	......	......
	v_L	1.8783	......	......	......	......	......	......	......	......	......
$t = 160$	v_J	2.0237	0.6646	0.3923	......	......	......	......	......	......	......
	v_L	2.0245	0.6643	0.3918	......	......	......	......	......	......	......
$t = 190$	v_J	2.1674	0.7146	0.4239	0.2992	0.2296	0.1852	......	......	......	......
	v_L	2.1695	0.7152	0.4240	0.2990	0.2293	0.1848	......	......	......	......
$t = 220$	v_J	2.3107	0.7639	0.4544	0.3217	0.2479	0.2009	0.1683	0.1443	0.1259	0.1113
	v_L	2.3137	0.7653	0.4550	0.3223	0.2483	0.2011	0.1683	0.1441	0.1256	0.1108
$t = 250$	v_J	2.4535	0.8127	0.4844	0.3437	0.2655	0.2157	0.1812	0.1558	0.1364	0.1210
	v_L	2.4571	0.8147	0.4860	0.3450	0.2665	0.2165	0.1818	0.1563	0.1368	0.1213
$t = 300$	v_J	2.6909	0.8932	0.5337	0.3795	0.2939	0.2993	0.2016	0.1739	0.1527	0.1359
	v_L	2.6954	0.8960	0.5361	0.3817	0.2959	0.2412	0.2034	0.1755	0.1543	0.1374

the investigation, which is not the case. It appears that there is some error common to all the equations of state of the form of [4], and the author thinks that the trouble is not with his values of R and v, but with the equation itself which, to be true, must be of a more complicated form like

$$\frac{pv}{T} = B - H(p, T) \quad \text{[5]}$$

The values marked v_L in Table are those (Table 9 in the original) determined from the experiments of Knoblauch, Linde and Klebe by means of the Linde equation within the range of the greatest applicability of this equation. The part within the heavy black line lies within the proper range of the determinations of Knoblauch-Linde-Mollier: there the difference between v_J and v_L does not exceed 0.25 per cent, while the error in v_L itself may be as high as 0.2 per cent. The agreement between the two sets of values is therefore a close one. For higher pressures in the range of superheat the difference is greater, due mainly to the fact that according to the Linde equation $R = 0$ at 405 deg. cent., while according to Jakob it does not reach the 0 value until 920. deg. cent. Where the Jakob values differ in the domain of saturation and higher pressures from those of Linde, they at the same time approach those calculated by Schüle from the determinations of Ramsay and Young, though the difference with respect even to these last values at 19 atmospheres is quite considerable (1.4 per cent); this is due to the fact that at that pressure R is nearly 10 per cent of the value of v, and an error in its determination, which may in itself be as high as 10 per cent, affects the value of v quite appreciably.

HEAT TRANSMISSION FROM FLOWING AIR TO PIPE WALLS (*Der Warmeübergang von strömender Luft an Rohrwandungen*, Grober. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 130, p. 1, 24 pp., 22 pp. *eA*). For preliminary notice of this investigation see *The Journal*, June 1912, p. 972). The author shows that the heat transmission is an exponential function of the velocity of flow and that the exponent of the latter in this case is 0.81. The relation between heat transmission and temperature of air and pipe walls is also expressed by exponential functions, but the exponents themselves vary with temperature. The author confirms the Nusselt statement as to the relation between the heat transmission and length of pipe (see *The Journal*, June 1912, p. 972), and finally establishes the following experimental formula:

$$\alpha = \left(3.81 + \frac{82.8}{t_L} - \frac{(273 - t_w)^2}{29{,}100}\right) \frac{(w\rho)^m}{D^{1-m}}$$

where α is the coefficient of heat transmission in calories per meter square per deg. cent. per hour; t_L temperature of the air in deg. cent.; t_w temperature of the pipe wall in deg. cent.; w velocity of the flow of air in meters per sec.; ρ specific weight of air in kg. per sq. m; D diameter of the pipe in m; m a constant for the pipe under test $= 0.81$. The formula was confirmed experimentally for a pipe of $D = 0.062$ m (say 2.5 in.) and for ranges of temperature: $t_w = 75$ to 250 deg. cent. (122 to 482 deg. fahr.) and $t_L = 100$ to 325 deg. cent. (212 to 617 deg. fahr.). See also the equation for α in the article quoted above.

HEATING PROCESS WITH GASES AND CATALYTICALLY ACTING BODIES (*Heizverfahren mit Gasen und katalytisch wirkenden Körpern*, Ludwig Schmidt. *Zeits. für Beleuchtungswesen*, vol. 18, no. 35, p. 427, December 20, 1912. ½ p., 3 figs. *d*). Description of a new process of combustion of gases patented in Germany in which a catalyser is used to maintain the constant combustion of the gas and air mixture. Full description of this process is not here given because neither the original article nor the patent specification mention what material is used as a catalyser.

Miscellanea

Exchange of Trained Apprentices (*Austausch ausgelehnter Lehrlinge*, O. Stolzenberg. *Werkstattstechnik*, vol. 7, no. 2, p. 49, January 15, 1913. *g*). The German works have found that often a man who has gone through an apprenticeship course in a concern which maintains such a course, sometimes at a great expense to itself, goes to another concern to work afterwards. In itself such a thing is natural, because the young man wants to see the world, sometimes to escape for a time from the home atmosphere (where the plant of his apprenticeship is near his home, as is often the case); in traveling he grows morally and mentally, and learns new processes and methods of work, so that when he comes back to the plant where he took the apprenticeship he is really a more useful man than he would have been had he stayed there all the time. The problem is therefore to make sure that he does come back, and to do this the Maschinenfabrik Augsburg-Nürenberg and the Ludw. Loewe & Co. A-G. have entered into an agreement according to which the apprentice who after the completion of his period of training expresses the desire to travel, is directed to the other concern; he is, however, requested to write to his old firm every three months telling them how he is getting on; the connection therefore remains, and the man knows that he is always welcome to come back.

ARTICLES UPON GAS POWER

(Prepared by the Gas Power Literature Committee)[1]

DIESEL MARINE ENGINES, THE STARTING OF. *The Engineer* (London), January 10, 1913. 2 pp., 8 figs. *cdpA.*

Various starting gears.

LIGHTSHIP, A MOTOR PROPELLED. *The Engineer* (London), January 3, 1913. *dpB.* 1 p., 3 figs.

Describes the lightship Elbe with 220 h.p., brake, reversible four-cycle, two-cycle Diesel engine.

DIE KUHLUNG DER VERBRENNUNGSKRAFTMACHINEN, Hans Windhoff. *Elektrotechnik und Maschinenbau,* October 20, 1913. ⅛ p.

Review of article on the cooling of internal-combustion engines in Der praktische Maschinen-Konstrukteur, September 12, 1912.

MARINE INTERNAL COMBUSTION ENGINES. *The Engineer* (London), January 3, 1913. 1½ pp. *cdpA.*

The year's work.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

REPORTS OF MEETINGS

CHICAGO MEETING, FEBRUARY 6

A meeting of the members of the Society in Chicago was held on February 6 at the rooms of the Western Society of Engineers, with about 65 members and guests in attendance.

The subject of the evening was Internal-Combustion Engines, E. T. Adams, chief engineer of the Rumely Company, Laporte, Indiana, being the first speaker. Mr. Adams spoke of his own experiences in this field, and discussed the possibilities of building large gas engine units, stating that in his opinion it would be practical to build a two-cylinder four-cycle engine of 5000-kw. capacity and that the cost per unit of such an engine would be as much cheaper when compared with the smaller sizes, as the present turbo-generators are cheaper than the small units. He discussed also the different fuels available for gas engine operation and showed that the supply of gasolene and other products of petroleum is very limited. He mentioned the difficulties of using by-product gas and stated that he thought the gas producer using pulverized coal offered many attractions which would no doubt lead to its successful production in time.

The last part of Mr. Adams' talk was devoted particularly to small engines such as he is working on at present; he brought out the fact that the power requirements of the farmer are very much larger than have heretofore been appreciated. In discussing the fuel available for the farmer's engine, he again spoke of the limited supply of gasolene and kerosene; he expects that the fuel of the future can be made entirely from the products of the farm, and that alcohol made from potatoes and other products, will be one of the main fuels. Government regulation is holding back the development along this line at present. Mr. Adams stated that practically all the forms of internal-combustion engine, including the Diesel, have the same records for economy.

Prof. Chas. R. Richards of the University of Illinois discussed the field of internal-combustion engines in general, and made particular reference to some recent experiments of Professor Parr, of the University of Illinois, on the low temperature distillation of bituminous coal driving off a heavy gas rich in by-products and leaving a "semi-coke," which he felt could be used in gas producers for power purposes. Professor Richards also discussed the fuel situation, agreeing with Mr. Adams that some fuel other than gasolene and kerosene would have to be developed in the near future.

J. C. Miller, consulting engineer, Chicago, described some of his experiences during the early days of gas engines and gas producers. He brought out the fact that many installations had failed because they had not been properly designed for the fuel, and that they had not been carefully operated.

Nisbet Latta, formerly with the Wisconsin Engine Company, spoke of his experience with gas producer gas engine installations, and described the difficulties encountered and prophesied, as did Mr. Adams, that a gas producer operated with pulverized coal would some day be perfected.

W. H. Hazard, and the following members of the Society, H. H. Wait, John M. Sweeney, and S. S. Howell, also took part in the discussion.

ST. LOUIS MEETING, FEBRUARY 5

At a meeting of the Associated Engineering Societies of St. Louis on February 5, held under the auspices of members of The American Society of Mechanical Engineers in that city, a paper on The Lubricating Value of Cup Greases was presented by the author, Prof. A. L. Westcott of the Missouri State University, Columbia, Mo., and illustrated by lantern slides. Professor Westcott described a number of tests of cup greases under a variety of conditions as to bearing pressure, temperature and method of application of the grease for coefficient of friction and general suitability as a lubricant. The paper was discussed by E. L. Ohle, John Hunter, G. R. Wadleigh, F. E. Bausch, and Mr. Schuyler. The meeting was largely attended.

A more complete account of the meeting will appear in a later issue of The Journal.

PHILADELPHIA MEETING, FEBRUARY 8

A meeting of the members of the Society in Philadelphia and vicinity was held in the Engineers Club of Philadelphia on February 8, 1913, A. C. Jackson, chairman of the local committee, presiding. About 175 members and guests were in attendance.

After the transaction of business, the paper of the evening, Overhead Expense Distribution, was presented by the author, Royal R. Keely, in which he discussed the various methods employed in computing this important item and their relative merits. It was discussed by Harrington Emerson, Henry Hess, Walter M. Kidder, J. F. Wickersham, Carl G. Barth, F. G. Coburn, F. C. Andrews, and A. C. Jackson.

A more extended account of the meeting will appear in a later issue.

NEW YORK MEETING, FEBRUARY 11

At a meeting of the New York membership in the Engineering Societies Building, on February 11, Wm. T. Donnelly presented a paper on Port Facilities for Ships in the United States, which was illustrated by lantern slides, in which he described the present situation in various ports and outlined the improvements which he considered necessary to make the facilities adequate. Mr. Donnelly's wide experience, as a representative of the State of New York on the Atlantic Deeper Waterways Commission and on the Inland Waterways Commission, as consulting engineer for the State of Connecticut in relation to their harbor matters, and also as consulting engineer for the work being done at Prince Rupert by the Canadian Pacific Railroad, and with many other similar activities, has given him the opportunity to study the question at first-hand, and supplied an added interest to the paper. The paper was discussed by H. McL. Harding, Harry Sawyer, Elias Cahn, George A. Orrok, F. L. Du Bosque and W. C. Brinton, and H. R. Cobleigh presided over the meeting.

A more extended account of the meeting will be published in a later issue of The Journal.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

At a regular meeting of the Armour Institute of Technology Student Branch on February 5, W. H. Green presented a paper on the Wiley Fuel Economy Gage, which indicates and records the relative efficiency of the boiler. Discussion followed in which many participated.

CASE SCHOOL OF APPLIED SCIENCE

At the meeting of the Council on February 14, the establishment of a new student branch at the Case School of Applied Science was authorized.

POLYTECHNIC INSTITUTE OF BROOKLYN

At a meeting of the Polytechnic Institute Student Branch on February 1, T. W. Reed of the engineering department of the General Electric Company gave a lecture on Steam Turbine Principles, Design and Operation, which was followed by discussion. On February 15 members of the branch made an excursion to the power plant of the Long Island Railroad.

PURDUE UNIVERSITY

On January 28, the meeting of the Purdue Student Section was addressed by Dean Benjamin on the Development of the Mechanical Arts, in which he pointed out that the present advanced stage was not achieved in a day but was gradually developed from the crude implements of our forefathers.

The following officers were elected for the semester: L. L. Savage, president; A. D. Meals, vice-president; S. A. Peck, treasurer; G. F. Lynde, recording secretary; A. S. Romig, corresponding secretary.

On February 11, H. S. Dickerson, Mem. Am. Soc. M. E., gave an interesting talk on the Apprenticeship Course for the College Graduate.

UNIVERSITY OF KENTUCKY

A meeting of the University of Kentucky Student Branch was held on February 7, when an illustrated lecture of the Steam Valve as a Metallurgical Problem was delivered by George K. Elliott, chief chemist and metallurgist of the Lunkenheimer Company of Cincinnati. Mr. Elliott drew attention to the latest practice in the mixture of bronze and brass alloys used in the manufacture of steam valves.

UNIVERSITY OF MISSOURI

The following officers were elected at the meeting of the University of

Missouri Student Branch on January 20: W. P. Jesse, president; R. Runge, secretary and treasurer; J. H. Pound, corresponding secretary. At the conclusion of business, Prof. L. M. Defoe gave an instructive talk on City Administration, which was followed by a general discussion.

UNIVERSITY OF NEBRASKA

The University of Nebraska Student Section have taken up with the faculty the matter of having an "engineers' night" when the laboratories will be open and running for the inspection of visitors, and a committee has been appointed to investigate its feasibility.

UNIVERSITY OF WISCONSIN

The following officers were elected at the January 23 meeting of the University of Wisconsin Student Branch: W. K. Fitch, president; G. B. Welser, vice-president; E. S. Gillette, secretary; W. H. Schleck, treasurer.

NECROLOGY

JOSEPH HARLAN FREEMAN

Joseph Harlan Freeman, consulting engineer and mechanical expert, died in Brooklyn on January 27, 1913, at the age of 44. As a boy he was obliged through the death of his father to leave school and become a printers' apprentice with the Tradesman Company, Grand Rapids, Mich. Dissatisfied with his lack of education, he applied for admission in the Michigan Agricultural College at the age of nineteen, and was graduated with the degree of B.S. in 1890. Upon completion of his course he became a designer and foreman with the Buss Machine Works of Grand Rapids, and designed several important new machines.

From 1891 to 1898 he served as an examiner in the Patent Office in Washington, studying law in the evenings at the Georgetown University. His early experience with printing machinery and his knowledge of the art caused him to be placed in that division of his department, and his good work soon attracted the attention of a firm of patent attorneys in New York, who engaged him to take charge of this phase of their own practice.

In 1903 he established an independent office as a consulting engineer and patent expert, which he conducted up to the time of his death.

CHARLES N. TRUMP

Charles N. Trump was born at Newport, Bucks County, Pa., on May 30, 1829, of Quaker parentage, and received his education in a private school of Alexandria, Va., his father having engaged in the lumbering business in Baltimore. In spite of opposition by his family, who wished him to enter one of the professions, which did not then include mechanical engineering, he apprenticed himself in one of the machine shops of Baltimore.

Naturally a student, Mr. Trump absorbed all the engineering information available, and becoming interested in gas engineering, opened an office in Philadelphia for the erection of gas works, especially to develop a system of manufacturing gas from resin. He erected several works in different parts of the country, but during the Civil War was obliged to abandon his business and to take up insurance. In 1865 he was engaged by Russell, Birdsall & Ward, Port Chester, N. Y., to take charge of a section of the works.

In 1870 he and his brother opened a machine business in the same town, under the name of Trump Brothers Machine Company, and developed a line of manufacture of foot-power scroll saws, special chucks, and other light machines. Two years later they moved the business to Wilmington, Del., considerably enlarging it and taking up the manufacture of knitting machinery. Mr. Trump retained for many years the presidency of the company, and retired only a short time before his death on December 30, at the age of 83.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The list of "men available" is made up from members of the Society and good men not members. Information will be sent upon application.

POSITIONS AVAILABLE

032 Assistant editor on the staff of a leading engineering journal. Must be a graduate in mechanical engineering with first-rate record as student and have had one to four years experience in engineering work. Ability to write clearly and concisely and possession of sound engineering judgment are essential. State age and give full record of education and past work with references; also salary expected. Apply through the Society.

033 Patent office draftsman for concern in Massachusetts. Must be competent to make up patent office drawings and write description either from the machines or assembly drawings.

034 Draftsman from $80 to $100 a month for manufacturers of special steel castings and machinery. Location, New Jersey.

035 Draftsman; technical education preferred. Experienced in design and layout of ore crushing and conveying machinery. Salary $125 to $150 a month.

036 Draftsman, experienced in locating and laying out pumping plants, pipe lines, etc. Technical education preferred. Salary $125 to $150 a month.

307 Man to take charge of car repairs; one with experience in this line preferred and with technical education. Salary $75 to $100 a month.

038 Large manufacturing concern wants several mechanical engineers with executive ability and experience in power house work and methods of shop practice. Location, Pennsylvania.

039 High-grade well trained energetic engineer to act as chief draftsman and designer in a new enterprise of experimental character. Location, Massachusetts. Apply through the Society.

040 Works manager for machinery manufacturing plant in England, employing 600 men in the production of pumping machinery of every type and size. Must be experienced in all branches of modern machine shop and foundry practice, and possess such engineering knowledge as successfully to meet local competition. Salary $5000 per year. Confidential, apply through the Society.

041 Manager to have charge of department manufacturing gasolene and

oil engines, employing about 1000 men. Must have experience in manufacturing in accordance with modern methods and ability to handle men and modernize systems employed in shop for economical and efficient production. Excellent position for right man. Location, Middle West.

042 Several first-class draftsmen on design of open-hearth steel, blast furnaces, rolling mill or allied work. Men capable of acting as leaders. New York concern.

043 First-class power house engineer, one familiar with both steam and electrical plants. Location, New York.

044 New York concern desires to arrange working agreement with engineers with experience in special fields of activity. Want a man exceptionally strong in designing improved machinery or perfecting machines now in use who will act as consulting engineer in such matter, *especially at this time.*

045 Young technical graduate preferred as draftsman on power-house layouts, piping, etc. Salary, $18 to $20 per week. Position will give good experience in above line and probably lead to advancement.

046 Experienced man wanted on scientific rate setting, time study and detailed analysis for concern manufacturing gas and gasolene engines and now operating shop under the bonus system. Location, Ohio.

047 Assistant engineering editor for company in Middle West. To the right man who has had experience in the preparation of copy for trade publications position would pay up to $175 a month. Applicant should be engineering graduate and if possible with experience in foundry and machine shop work; training along iron and steel lines desirable.

048 Draftsmen, preferably with experience in mechanical lines, particularly power plant machinery and piping, boilers, boiler settings, etc. Location, Connecticut.

MEN AVAILABLE

38 Junior member, age 30, technical graduate, with seven years' experience in the design, construction, operation and maintenance of power plants and substations and in testing electrical machinery; desires position of responsibility with hydroelectric company or with contractors doing power plant or hydroelectric work. Best references. $150-$200 per month. At present employed.

39 Man familiar with presses, dies and other tools for manufacturing sheet-metal goods, has given considerable attention to efficient manufacturing and the design of special machinery and tools.

40 Factory man and engineer, now head of engineering department of large company, desires position as works manager, preferably with new company.

41 Junior member, A. B. Yale, M. E. Columbia, would like to associate with engineer or firm making specialty of design and construction of industrial plants. Experience in this line as superintendent of construction, assistant to works manager, etc.

42 Junior member, technical graduate, age 30, experienced in crane and hoisting machinery design, desires position with progressive firm as designing engineer or chief draftsman. Can show results in improved efficiency of drafting room.

43 Technical graduate, age 37, practical mechanic with 10 years experience in executive capacity, mill engineering, power generation, transmission, etc.; desires position with large progressive concern in New England as factory engineer or works manager.

44 Mechanical and architectural engineer, age 32, desires position in New York City, preferably with manufacturing concern or with firm of architects. Familiar with industrial and power plant engineering. Assoc. Mem.Am.Soc.C.E. Licensed architect State of Illinois.

45 Member, Stevens Inst. Tech. graduate, 16 years engineering and executive experience, desires position as purchasing agent, sales supervising or production engineer, or office manager with some growing concern.

46 Member desires position as works manager; technical graduate, 15 years manufacturing experience; successfully carried entire managerial responsibility. Executive ability, thoroughly able to develop factory organization in most modern methods of control of production. Familiar with high-grade interchangeable and precision work in quantity. Highest credentials.

47 General superintendent with thorough practical experience in organizing, directing production, tactful management, plant layouts, interchangeable manufacture, machine and tool design, and practical application of modern efficiency methods in electrical, machine and tool lines; desires change to better position with opportunity of further advancement.

48 Member, age 34, technical graduate, 11 years experience machine shop, designing, manufacturing, erecting, and selling hydraulic turbines, governors, penstocks, etc. Experienced in making examinations, efficiency tests and reports of electric power plants, well grounded in electrical and steam engineering. At present employed but desires change. Prefers position with consulting engineer or public utilities corporation.

49 Graduate mechanical engineer, who has been following editorial work, wishes position in similar line or in connection with technical advertising. Would be interested to hear of any selling positions with good prospects for the future. Best of references as to ability and character.

50 Sales manager, exceptional experience selling boilers, engines and complete power plants as well as their design, construction and installation. Specially good at getting results from branch offices and salesmen. Valuable acquaintance gained by 15 years successful selling in territory east of and including Pittsburgh and Buffalo. Member with both practical and technical training.

51 Manager or engineer capable of taking charge of sales department, advertising and correspondence or shop.

52 Thoroughly competent refrigerating engineer open for an engagement. Familiar with absorption and compression machines, refrigerating and ice making in all details. Designing, construction and operation. Valuable experience.

53 Junior, graduate mechanical engineer, 10 years experience as superintendent construction. Master mechanic in large factory; past three years with beet sugar company in charge of designing, constructing and operating numerous pumping plants, irrigation systems, pipe and power lines, accustomed to figuring cost and purchasing materials. Executive ability and excellent references; desires to make change about May 1.

54 Member, age 39, long practical experience including a year and a half in Europe, now associate professor of mechanical engineering, desires similar position in a growing university.

55 Junior member, age 28, twelve years experience on open-hearth furnace and fuel gas producer plants, designer and resident engineer of construction, desires a position of responsibility with a chance of advancement.

56 Associate, M. I. T. graduate, 25 years experience in miscellaneous engineering, designing and manufacturing work, some office and selling experience; desires position in Chicago.

57 Member with successful experience in high-grade interchangeable manufacture, desires position as superintendent or assistant in manufacturing plant. Especially familiar with steam turbine work. Available April 1.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

ERROR IN FEBRUARY ISSUE

Through an error in The Journal for February, the gift of the Una-Flow Steam Engine by J. Stumpf, was credited to Edward H. Trump instead of Edward N. Trump.

Air Brake Association. Proc. annual conventions 16–17, 19. 1909, 1910, 1912. *1909, 1910, 1912.*

———Standard Form of Questions and Answers on the Westinghouse Air Brake for Beginners and Advanced Students. 1913. *Boston, 1913.*

American Gas Furnace Company. Automatic Heat Controller. Invented by Geo. F. Machlet. *New York.* Gift of company.

American Railway Association. Proc. Chicago session, November 20, 1912. Gift of association.

American Water Works Association. Proc. 32d annual convention, 1912. *Troy, 1912.* Gift of association.

Atlantic Deeper Waterways Association. Report of Proc. 5th annual convention, September 4–6, 1912. *Philadelphia, 1912.* Gift of association.

Ballon-und Flugmotoren, A. Haenig. *Rostock i. M., 1910.*

Boston Transit Commission. 18th annual report, 1912. *Boston, 1912.* Gift of commission.

Car Builders' Dictionary. ed. 7, 1912. *New York, 1912.*

Concerted Movement of the Railways, Logan G. McPherson. Reprinted from the North American Review, January 1913. *New York, 1912.* Gift of author.

Concrete and Constructural Engineering. vols. 1–5, 1906–1910. *London, 1906–1910.*

Condensed Catalogues of Mechanical Equipment including designs and data, reprinted from the advertising section of The Journal of The American Society of Mechanical Engineers. vols. 1–2. *New York, 1912.*

Corrosion of Iron and Steel, Alfred Sang. *New York, 1910.*

Creation of Organization with Special Reference to Personnel, Harrington Emerson. *New York, 1913.* Gift of Efficiency Society.

Dampfturbinen. Manufactured by Gebrüder Sulzer. *Winterthur-Ludwigshafen.* Gift of G. Sulzer.

Detroit. Board of Water Commissioners. 60th annual report. *Detroit, 1912.* Gift of board.

ELEVATOR SHAFT CONSTRUCTION, H. R. Cullmer. *New York, 1912.*

ENGINEERING AND METALLURGICAL BOOKS, 1907–1911, R. A. Peddie. *New York, D. Van Nostrand Co., 1912.*

The author in his preface calls attention to the lack of enterprise on the part of publishers in neglecting to notify the public of the fact that they have published a book. He has brought together all the discoverable titles on the subjects indicated during five years, and in doing so has rendered a very valuable service, particularly as he gives paging, publisher and price. The arrangement is by subject, and has a good author index.

ENGINEERING THERMODYNAMICS, C. E. Lucke. *New York, 1912.*

EXPERIMENTAL INVESTIGATIONS ON THE POWER REQUIRED TO DRIVE ROLLING MILLS, J. Puppe. *London, 1910.*

FALL RIVER WATER WORKS. 39th Report of the Watuppa Water Board to the City Council, January 1, 1913. *Fall River, 1913.* Gift of water works.

FARM ENGINES AND HOW TO RUN THEM, J. H. Stephenson. *Chicago, 1910.*

FARM MACHINERY AND FARM MOTORS, J. B. Davidson and L. W. Chase. *New York, 1912.*

FREIGHT TERMINALS AND TRAINS, J. A. Droege. *New York, 1912.*

GASOLINE ENGINE ON THE FARM, X. W. Putnam. *New York, Norman W. Henley Publishing Co., 1913.*

This is a book that has been greatly needed. The time is not far distant when farm wastes and farm crops, now fed to horses, will be made into alcohol and this used for fuel in explosive engines. The descriptions are clear and concise, and the uses of the engine on the farm are startling in their number.

GÉNIE CIVIL, vol. 32, vol. 52, no. 6. *Paris, 1897–1898, 1907.*

GESCHICHTE DER FIRM GEBRÜDER SULZER WINTERTHUR UND LUDWIGSHAFEN A. Rh., Conrad Matschoss. *Berlin, 1910.* Gift of Gebrüder Sulzer.

GIRDERS FOR ELECTRIC OVERHEAD CRANES, R. B. Brown. ed. 2. (Machinery's ref. ser. no. 49.) *New York, 1910.* Gift of Hunt Memorial Fund.

GREEK-ENGLISH—ENGLISH-GREEK LEXICON, N. Contopoulos. 2 vols. ed. 5. *Athens, 1904, 1907.*

HANDBOOK OF ENGLISH FOR ENGINEERS, W. O. Sypherd. *Chicago-New York, Scott, Foresman & Co., 1913.*

The author is professor of English in Delaware College, and the work is designed for students of engineering and young engineers. Only one who has edited the writings of engineers and scientists can realize to the fullest extent the value of the work. Every engineer will be the better engineer after he has read it, for he will be able to write better letters, better reports, and better articles for the technical press.

DIE HÄNGE UND SPRENGWERKE UND IHRE EINFLUSSLINIEN, Otto Seyller. *Leoben, 1913.*

HELICAL AND ELLIPTIC SPRINGS. (Machinery's ref. ser. no. 58.) *New York, 1910.*

IGNITION, WITH ORIGINAL DIAGRAMS AND PHOTOGRAPHS, C. A. Pfanstiehl. *Cleveland, 1912.*

INTERNATIONAL RAILROAD MASTER BLACKSMITHS ASSOCIATION. Proc. 20th annual convention. *Lima, O., 1912.* Gift of association.

LATHE WORK. A practical treatise, P. N. Hasluck. *London, 1904.*

LEHRBUCH DER BAUMATERIALIENKUNDE, Max Foerster. vol. 5 and 6. *Leipzig, 1912.*

LEHRBUCH DER THERMODYNAMIK, J. D. Van der Waals. vol. 2. *Leipzig, 1912.*

DIE LOKOMOTIVEN DER GEGENWART, Baumann, Courtin and others. ed. 3, pt. 1. *Wiesbaden, 1912.*

Die Maschinenfabrik R. Wolf, Magdeburg-Buckau 1862–1912, Conrad Matschoss. Gift of R. Wolf.

Machine Design, Hoists, Derricks, Cranes, H. D. Hess. *Philadelphia-London, 1912.* Hunt Memorial Fund Gift.

Metal Spinning. (Machinery's ref. ser. no. 57.) *New York, 1910.*

National Brick Manufacturers' Association. Official Report 26th Annual Convention, held at Chicago, Ill., March 6–8, 1912. *Indianapolis, 1912.* Gift of C. W. Rice.

New Process of Case Hardening by Gas invented by Adolph W. Machlet. *New York.* Gift of P. E. Osterman.

New York Air Brake System with Questions and Answers. *Chicago, 1911.*

Official Guide of the Railways and Steam Navigation Lines of the United States, Porto Rico, Canada, Mexico and Cuba. January 1913. *New York, 1912.*

Pan American Union, Peace, Friendship, Commerce, John Barrett. *Washington, 1911.* Gift of Pan American Union.

Press Tool Kinks. Compiled by F. H. Colvin and F. A. Stanley. *New York, 1908.*

Report on Growth of Traffic and Investment in Transit Facilities to the Board of Supervisors City of San Francisco, B J. Arnold. Preliminary report no. 19, January 2, 1913. Gift of author.

Report on Improvements in Existing Rolling Stock to Board of Supervisors City of San Francisco, B. J. Arnold. Preliminary report no. 7, pt. 2. . January 20, 1913. Gift of author.

Scientific Selection and Assignment of Men in the Creation of an Organization, Katherine M. H. Blackford. *New York, 1913.* Gift of Efficiency Society.

Slovnik Cesko-Anglicky s úplnou Anglickou Vyslovnosti, Karel Jonás. A Bohemian and English Dictionary. *Racine, Wis., 1886.*

Sugar at a Glance. Charts and Data, T. G. Palmer. *Washington, 1912.* Gift of U. S. Senate.

Technische Thermodynamik, W. Schüle. vol. 1, ed. 2. *Berlin, Springer, 1912.*

Textbook of Farm Engineering, John Scott. *London.*

Tool Steel: A concise handbook on tool-steel in general, Otto Thallner. *Philadelphia-London, 1912.*

Treatise on the South American Railways and the Great International Lines. Published under the auspices of the Ministry of Foment of the Oriental Republic of Uruguay. *Montevideo, 1893.* Gift of Oficina de Deposito Reparto y Canjo Internacional.

Turbines à Vapeur. Manufactured by Sulzer Frères. *Winterthur (Suisse).* Gift of Sulzer Frères.

U. S. Library of Congress. Building and Grounds. Letter from the superintendent of library buildings and grounds, transmitting preliminary plans and estimates of cost of a central power station for existing and projected government buildings on the mall and in the vicinity of the White House. *Washington, 1905.* Gift of Library of Congress.

U. S. Light House Commissioner. Annual Report, 1912. *Washington, 1913.* Gift of U. S. Lighthouse Commissioner.

———Annual Report to the Secretary of Commerce and Labor, 1911. *Washington, 1911.* Gift of Light House Board.

UNIVERSITY OF PITTSBURGH. Celebration of the 125th anniversary. *Pittsburgh. 1912.* Gift of University of Pittsburgh.

VAPORS FOR HEAT ENGINES, W. D. Ennis. *New York, 1912.*

VECTOR ANALYSIS. An introduction to Vector-methods and their various applications to Physics and Mathematics, J. G. Coffin. ed. 2. *New York, 1911.*

VEHICLES OF THE AIR, Victor Lougheed. *Chicago, 1909.*

VEREIN BERATENDER INGENIEURE. Die Beratenden Ingenieure im Auslande, ihre Organisationen und ihre Gebührensätze, Kurt Perlewitz. *Berlin, 1912.*

———Mitglieder-Verzeichnis. June 1912.

———Satzung. Gift of Verein Beratender Ingenieure.

WATER SUPPLY SYSTEM OF THE SPRING VALLEY WATER COMPANY, SAN FRANCISCO, CAL. Report, H. M. Chittenden and A. O. Powell. Gift of company.

WESTINGHOUSE AIR BRAKE SYSTEM, WITH QUESTIONS AND ANSWERS. *Chicago, 1911.*

WHAT TO READ ON BUSINESS. *New York, 1912.*

WILLIAMS COLLEGE. Bulletin, September and November 1912. *Williamstown, 1912.* Gift of college.

ZOELLY STEAM TURBINE FOR LAND USE. Gift of Escher Wyss & Co., Zurich.

GIFT OF DR. WM. PAUL GERHARD, C. E.

AHLBURG. Der Strassenbau mit Einschluss der Construction der Strassenbrücken. *Braunschweig, 1870.*

ALBRECHT, H. Das Arbeiterwohnhaus. *Berlin, 1896.*

ASSOCIATION OF ENGINEERING SOCIETIES. Journal, vol. 10, no. 13; vol. 11, no. 12; vol. 12, no. 12; vol. 13, nos. 9, 12. *Chicago, 1891–1894.*

BOSTON. STATE BOARD OF HEALTH. Report of the Joint Board upon the Improvement of Charles River, 1894. *Boston, 1894.*

———Report upon the Improvement of Neponset River, 1897. *Boston, 1897.*

BARTLETT, J. R. AND OTHERS. Outline of Plans for furnishing an Abundant Supply of Water to the City of New York. *1888.*

BACHMANN, H. Beitrag zur Messung von Luftmengen. *Heidelberg, 1912.*

BARTELS, H. Bericht über einige sogenannte Secundairbahnen, insbesondere Schmalspurbahnen in Amerika. *Berlin, 1878.*

BAUERNFEIND, C. M. v. Elemente der Vermessungskunde. vols 1–2. *Stuttgart, 1876.*

BELOE, C. H. On the Construction of Catch-Water Reservoirs in Mountain Districts. *London, 1872.*

BERLIN. Königliche Technische Hochschule. 39 photographische Aufnahmen nebst erlauterndem text. *Berlin, 1903.*

BERNOULLI. Dampfmaschinenlehre. *Stuttgart, 1877.*

BROOKLYN ENGINEERS' CLUB. Proceedings, 1898–1910. *Brooklyn, 1898–1911.*

BROOKLYN. DEPARTMENT OF CITY WORKS. Report on Future Extension of Water Supply for Brooklyn, 1896.

BROSIUS, J. Erinnerungen an die Eisenbahnen der Vereinigten Staaten von Nord-Amerika. *Wiesbaden, 1885.*

DEBAUVE, A. Manuel de l'Ingénieur des Ponts et Chaussées. bk. 5. *Paris, 1872.*

DOLL, M. Die Nivellirinstrumente und deren Anwendung. *Stuttgart, 1876.*

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Washington University	Mar.10, 1911	E. L. Ohle	D. Southerland	A. Schleiffarth
Yale University	Oct. 11, 1910	L. P. Breckenridge	C. E. Booth	O. D. Covell

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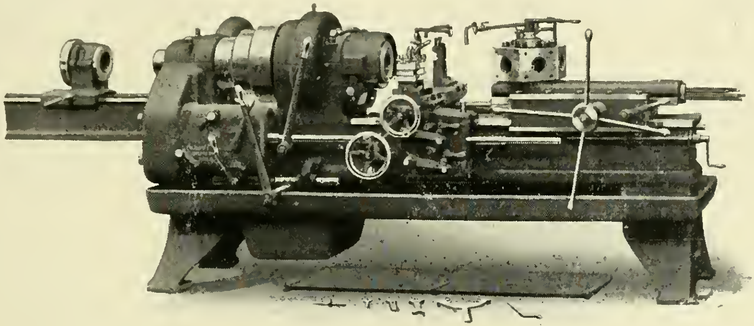

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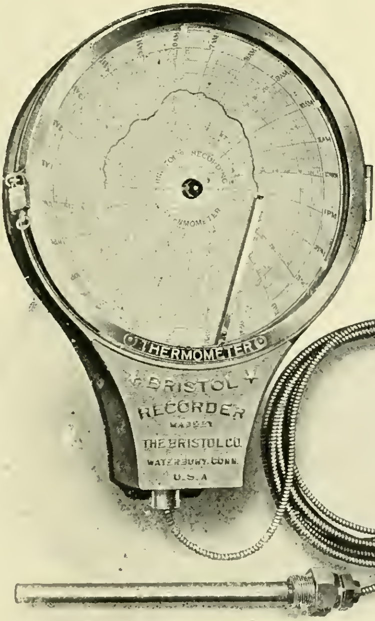

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FIG. 1 illustrates the advantage of the *double stop* for each position of the turret, and the *double* adjustment of each turner. This piece has six finished diameters and six shoulders, and is turned by only three turners, which occupy only three positions on the turret. This not only leaves the remaining positions free for other tools, but it saves the operator the time and energy required to run the turret slide back each time.

All this is obtained without complication, and without introducing any features that are annoying when not in use.

In addition to the double stop for each of the six positions of the turret, we have an extra stop, consisting of a pin which may be dropped into any one of the six holes at the rear of the turret slide. This makes it possible to borrow five extra stops for any one of the tools, and gives to this tool seven length or shoulder stops, and leaves one stop for each of the remaining tools.

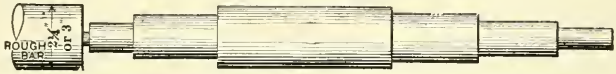

FIG. 1

The illustrations, Figs. 2 and 3, give examples of what one tool can do in this machine on chuck work, when we take advantage of the seven length stops and the seven shoulder stops of the cross-feed head.

Of course, in general practice three or four stops for one tool are all that will be needed, but since the modern cutting steels have greater durability, there is nothing lost by giving each tool all the work it can do.

Outer face and all shoulders and diameters accurately finished to independent stops by one tool. When roughing and finishing cuts are required, the roughing tool can be set near enough to use the same stops that are accurately set for the finishing tool. When an extra tool is used to give a roughing cut it is set as indicated by dotted lines in Figs. 2 and 3.

We find it difficult to illustrate all of the classes of work that can be turned out by this machine, but a little thought will suggest

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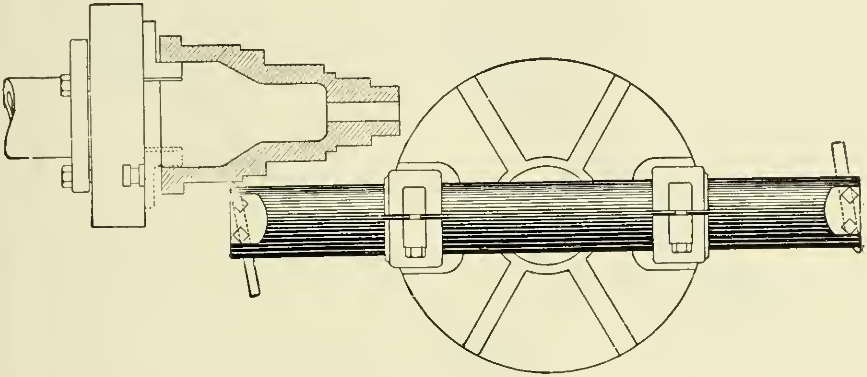

FIG. 2

many forms that may be readily handled in bar and chucking work, both steel and iron, on account of the many provisions for bringing both turret and cross slide up to fixed stops; either by power feed or by hand.

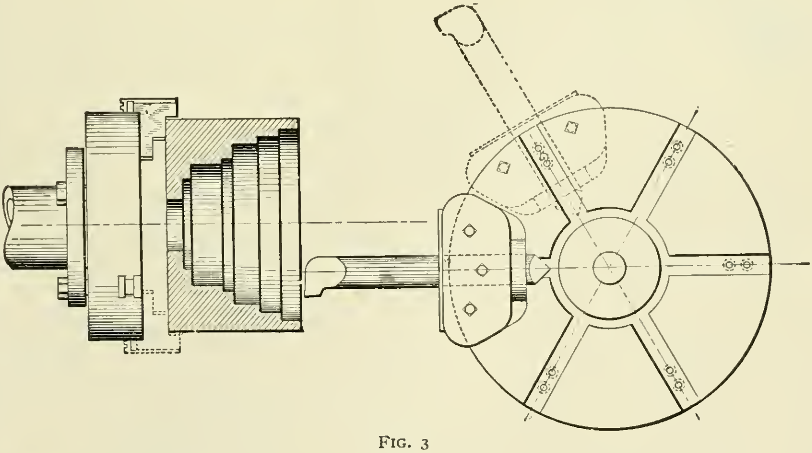

FIG. 3

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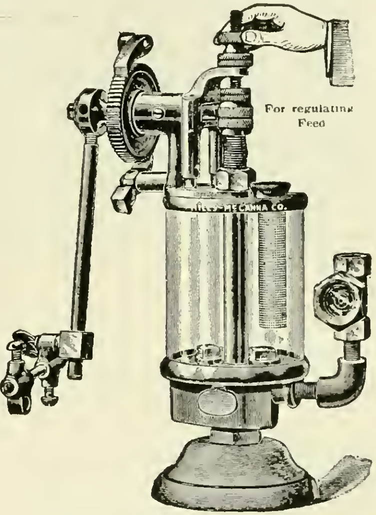

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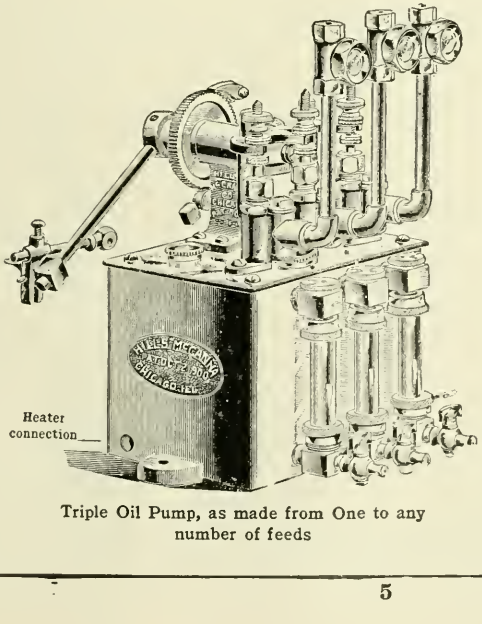

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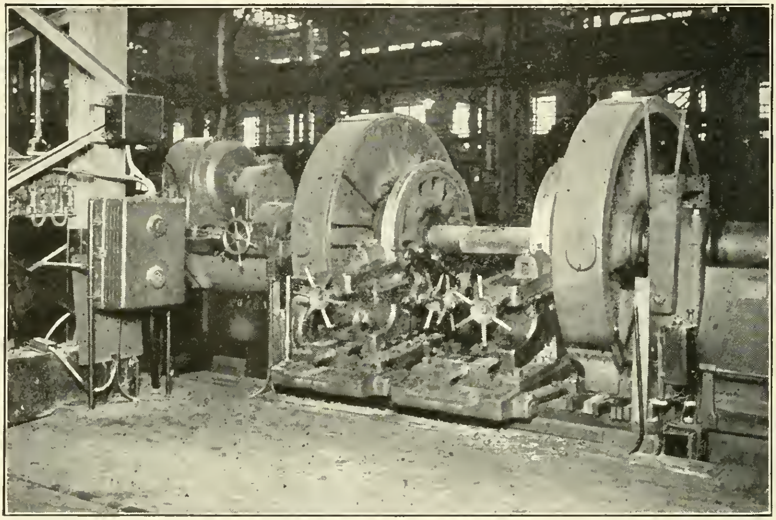

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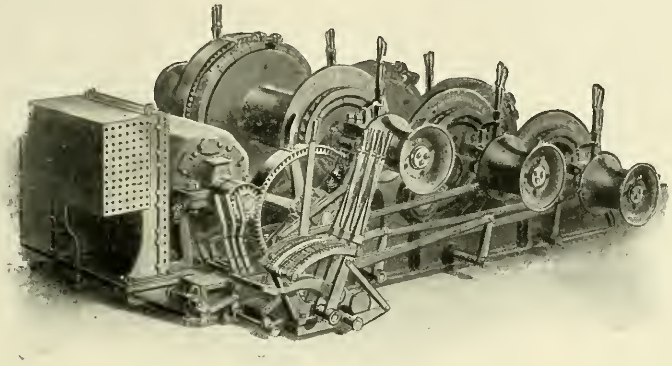

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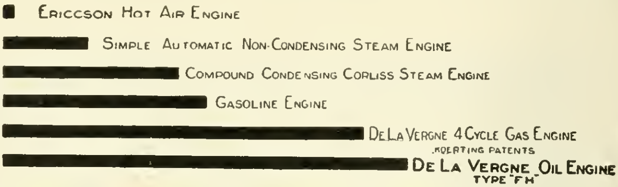

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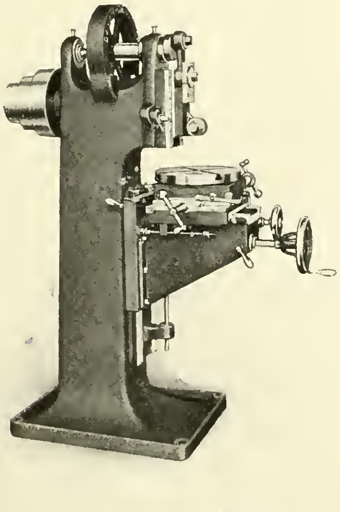

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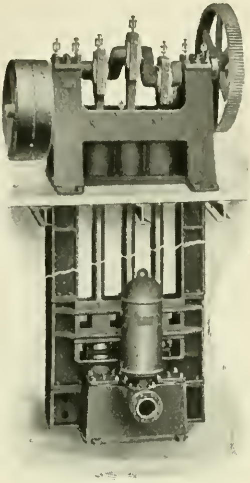

Fig. 1455.

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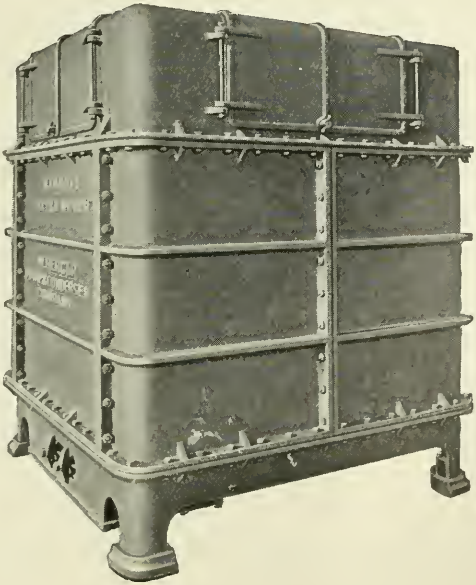

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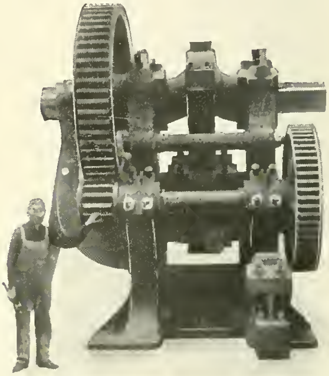

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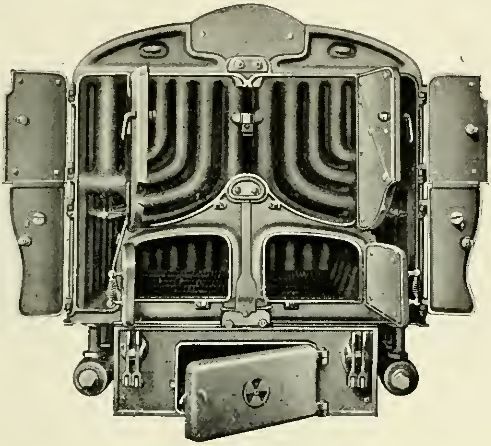

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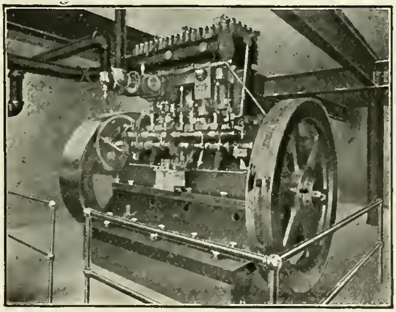

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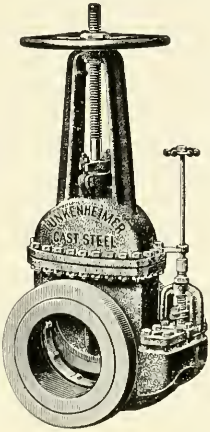

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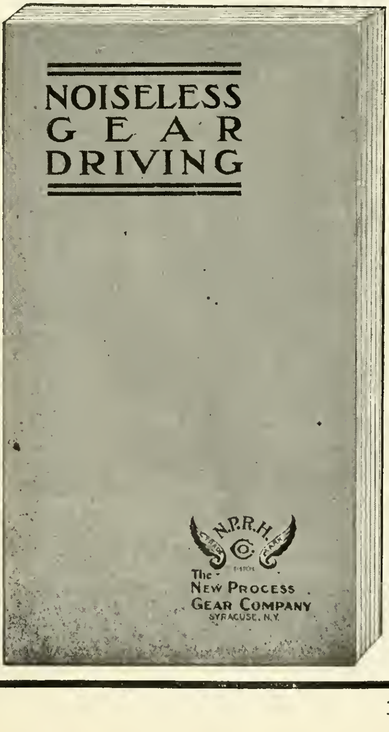

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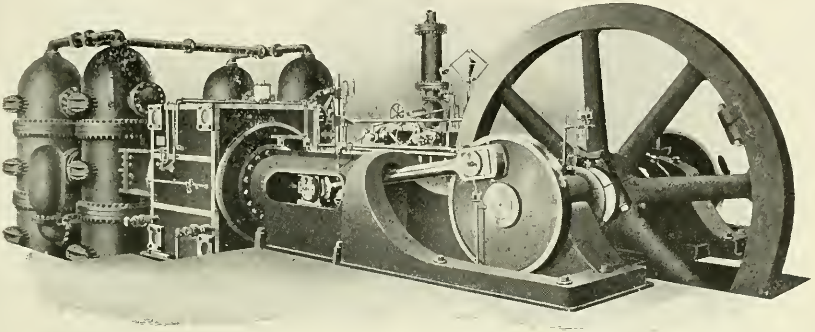

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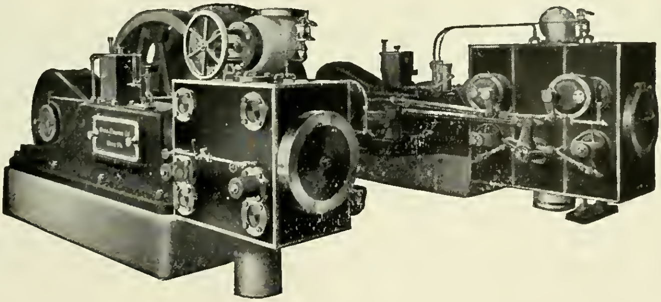

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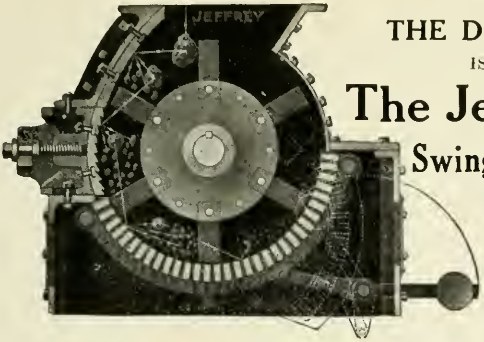

Sectional View, Showing Drop Bottom Bars, Adjustable Breaker Plate and Top Feed.

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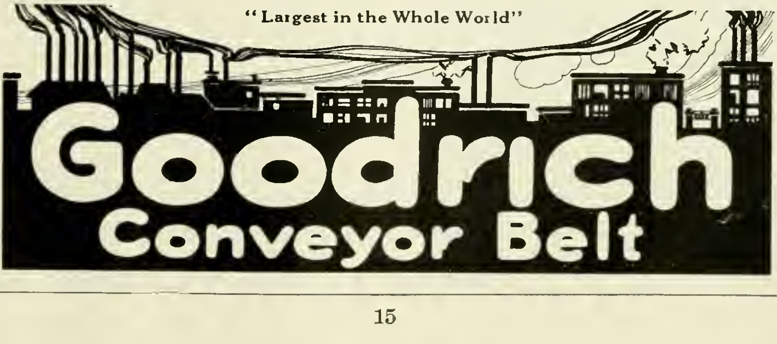
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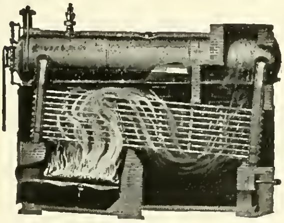

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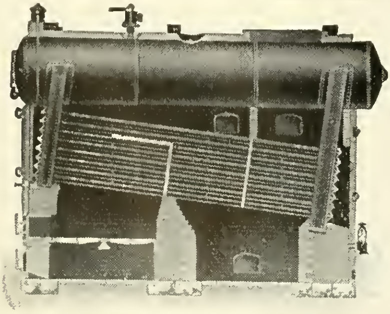

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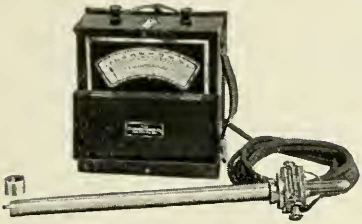

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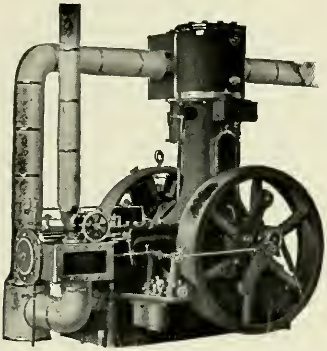

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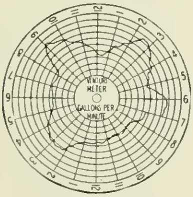

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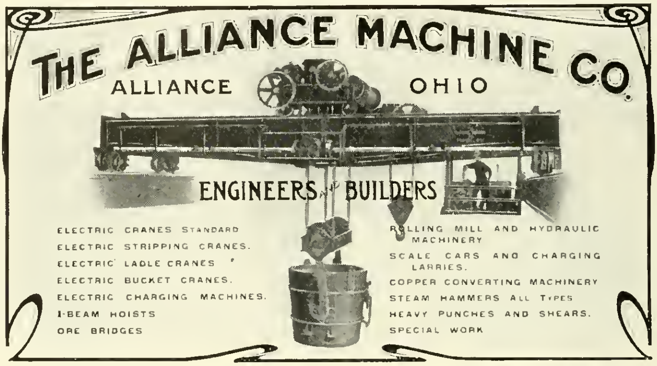

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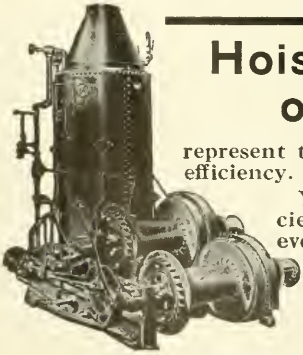

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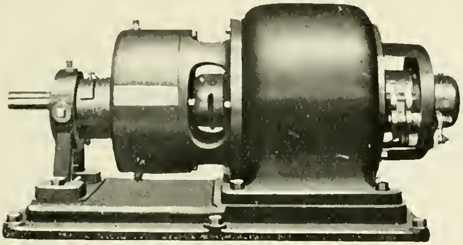

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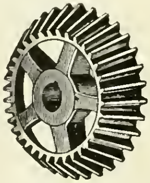

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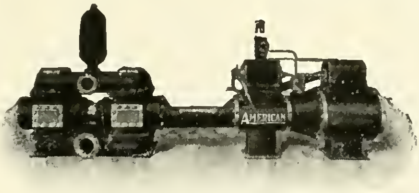

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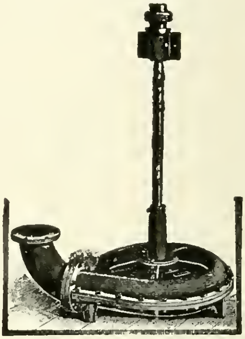

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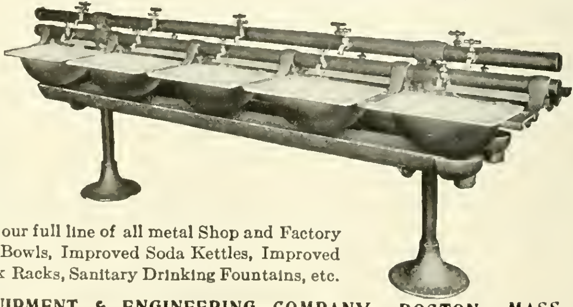

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THE
JOURNAL
of
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

APRIL 1913

35 CENTS A COPY $3 A YEAR

LOCAL MEETINGS: NEW YORK, APRIL 4 AND 8; PROVIDENCE, APRIL 10; NEW HAVEN, APRIL 16; BOSTON, APRIL 25. SPRING MEETING: BALTIMORE, MAY 20–23. MEETING IN GERMANY: JUNE 21–JULY 8

A MEMBERSHIP OVER FIVE THOUSAND

As a result of the increased interest on the part of the membership, a large number of new members will be added to the Society at the Spring Meeting. A list has recently been submitted to the voting membership containing the records of 619 candidates. Provided all of these candidates are declared elected, the membership will be 5102, a net gain since the corresponding period last year of 26 per cent.

This additional strength will enable the Society to undertake additional activities, will increase the value of membership, and, it is also hoped, will be a means of encouraging the membership generally to coöperate with the Committee on Increase of Membership in carrying out its plan to secure the active interest of every well-qualified engineer in America.

If each member will send the Committee the names of those he deems eligible for membership in the Society, the growth of the past few months will be certain to continue. Those who are in a position to serve on a local committee are invited to communicate with the chairman having charge of the district in which they are situated. Sub-committees have already been established in over a dozen geographical centers (see page 733).

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chmn.*
H. V. O. Coes
F. H. Colvin
J. V. V. Colwell
R. M. Dixon
W. R. Dunn
J. P. Ilsley
E. B. Katte
R. B. Sheridan
H. Struckmann

COMING MEETINGS OF THE SOCIETY

April 4, *New York City*, Engineering Societies Building. Joint meeting with the American Institute of Mining Engineers and the American Institute of Electrical Engineers, under the auspices of the New York Local Committees of the three societies. Private demonstration of the Edison Talking Moving Pictures, through the courtesy of the American Talking Moving Picture Co. and Mr. Thomas A. Edison, Hon. Mem. Am. Soc. M. E. Members only will be admitted and cards of admission will be required.

April 8, *New York City*, Engineering Societies Building. In charge of the Sub-Committee on Railroads. Subject: Steel Car Construction. See further details on page 5. Informal dinner 6.30 p. m., Keen's English Chop House, 70 West 36th St. Kindly notify H. R. Cobleigh, 505 Pearl St., of intention to be present.

April 10, *Providence, R. I.*, Crown Hotel, annual engineering dinner of the Providence Association of Mechanical Engineers and The American Society of Mechanical Engineers. Reception at 6.30 p. m.; dinner, 7.30 p. m. Prof. C. F. Scott of Yale University will be the principal speaker. The Society will be represented by Dean W. F. M. Goss, President, and Calvin W. Rice, Secretary. Tickets, $2.50.

April 17, *New Haven, Conn.*, Mason Laboratory, Yale University. Subject for afternoon session, 3 p. m.: Factory Heating, paper by A. C. Staley of Sheffield Scientific School; for evening session, 7.30 p. m.: Factory Lighting, paper by Clarence E. Clewell, of Sheffield Scientific School. Dinner in Yale Dining Club, 6 p. m.

April 25, Boston, Mass. Joint meeting with Boston Section of American Institute of Electrical Engineers and Boston Society of Civil Engineers. Paper, The Delivery and Handling of Freight at Boston Freight Terminals, by Harold Pender, H. F. Thomson and C. P. Eldred.

May 20–23, *Baltimore, Md.*, Spring Meeting. Headquarters, Hotel Belvedere. See Tentative Program on page 3.

June 21—*July* 8, Joint Meeting with Verein deutscher Ingenieure, Leipzig, and various industrial cities of Germany. See page 8 for Tentative Program.

APRIL 1913 VOL. 35 No. 4

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

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The Journal is published monthly by The American Society of Mechanical Engineers.

Price, 25 cents a copy, or $2 a year, to members and affiliates of the Society; 35 cents a copy or $3 a year to all others. Postage to Canada, 50 cents additional; to foreign countries, $1 additional.

Entered as second-class matter, January 4, 1912, at the Postoffice, New York, N. Y., under the act of March 3, 1879.

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THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 35 APRIL 1913 NUMBER 4

The Society wishes to secure copies of the following issues of The Journal: January 1911, October 1911, November 1912. These will be purchased from members at 25 cents a copy, provided they are in good condition.

SPRING MEETING

There should be a large attendance at the Spring Meeting in Baltimore, which is to be held May 20-23, in view of the very complete arrangements which have been made by the Local Committee, Layton F. Smith, Chairman. The excursions will be of such a character that all will wish to participate in them, thus affording a splendid opportunity for the members to get together on each day of the convention. The engineering work which has recently been in progress at Baltimore in connection with the high-pressure fire system and the sewage system, will be of particular interest, and the trip to Annapolis should afford a day of rare enjoyment.

The headquarters of the Society, both for the professional sessions and for social events, will be the Hotel Belvedere. At this season of the year many visitors are in Baltimore, and members are strongly advised to secure reservations in advance by writing directly to the hotel. Besides the Belvedere there is the Hotel Stafford, three and one-half blocks away, and the Hotel Emerson, which is an eight minute ride on the trolley.

As usual the registration will begin on Tuesday, the 20th, and the meeting will open with an informal reception on the evening of that day. There will be professional sessions Wednesday and Thursday mornings only, unless it should be necessary to continue any of these into the afternoon.

The Local Committee have a carefully worked out program, comprising a series of excursions which are most attractive. The first of these will be on Wednesday afternoon, when there will be an excursion to the high-pressure pumping station, used for the new fire system of Baltimore, after which the guests are invited to witness an exhibition of the fire system. They will then be taken on a sail about the harbor to inspect the water front, shipping facilities and other things of interest.

On Thursday afternoon, there will be alternative excursions with an opportunity to inspect the new sewage pumping plant and the sewage disposal plant, both of which are among the most modern and complete in the country. On this afternoon, the ladies will be taken in automobiles for a tour about the city and to the country club, where tea will be served.

On Friday there will be an all-day excursion to Annapolis. In order to save time for a visit to the various buildings, the trip will be made by trolley. Upon arrival, the party will proceed to the State House, to be received by the Governor of Maryland. An address will then be given by Admiral H. I. Cone, engineer-in-chief of the Bureau of Steam Engineering, U. S. N., upon the United States Experimental Station at Annapolis. There will be luncheon at the Carvel House and the afternoon will be left free for the visit to the Naval Academy and to the experimental station. There is a possibility that there will be hydroaeroplane flights by officers and men of the aviation school, and evolutions of the submarine boats stationed at Annapolis.

The professional session on Wednesday morning will be opened with the usual business meeting and a presentation of several important and interesting reports of technical committees of the Society, followed by papers upon the miscellaneous subjects of Patents, the Performance of Automobile Trucks, and Mechanical Drawing. Simultaneously with this, there will be a session conducted by the Gas Power Section.

On Thursday, a session will be devoted to the topic of Fire Protection, in charge of the sub-committee upon this subject.

A lecture of a popular nature will be delivered on Wednesday evening, and the local committee have under consideration several topics of absorbing interest from which they will make a selection. Thursday evening will be the main reception and dance at the Belvedere.

This year the visiting members will be charged for luncheons and the car fare for excursions, thus relieving the local members of any burdensome expenditure in connection with the entertainment of their guests. It is believed that the visiting members will welcome the opportunity to contribute the small amount involved.

RAILROAD MEETING

The Society will hold a meeting under the direction of the sub-committee on Railroads on April 8, in the Engineering Societies Building, New York, on Steel Passenger Car Design and Equipment. The meeting is intended to bring before the membership the very latest developments of the art by specialists in each feature of steel passenger car design, and is the first meeting of the kind to be held by the Society.

The first session under the direction of this sub-committee took place at the Annual Meeting of the Society in December 1912, at which were considered the factors involved in the Selection of Locomotives and Train Lighting. Its success has led to the arrangements for the present meeting. The meeting will be open to all and representatives of various railroad organizations are expected to attend. An informal dinner at Keen's Chop House, 70 West 36th Street, will precede the meeting and all who wish to participate should meet in the rooms of the Society at 6.15 p.m.

The following is a list of those who will present papers and the phases of the subject which they will discuss:

Introduction to General Discussion of Steel Passenger Cars, H. H. VAUGHAN, assistant to vice-president, Canadian Pacific Railway.

The Problems of Steel Passenger Car Design, W. F. KIESEL, JR., assistant mechanical engineer, Pennsylvania Railroad Company.

Underframes for Steel Passenger Cars, J. McE. AMES, American Car and Foundry Company.

Roof Structure for Steel Cars, C. A. SELEY, mechanical engineer, Rock Island Lines.

Suspension of Steel Cars, E. W. SUMMERS, president, Summers Steel Car Company.

Six-Wheel Trucks for Passenger Cars, J. A. PILCHER, mechanical engineer, Norfolk & Western Railway.

Steel Interior Finish for Steel Passenger Cars, **Felix Koch**, mechanical engineer, Pressed Steel Car Company.

Steel Interior Finish for Steel Passenger Cars, **Marvin Singer**, assistant mechanical engineer, Pullman Company.

Painting of Steel Passenger Cars, C. D. **Young**, Engineer of Tests, Pennsylvania Railroad Company.

Provisions for Electric Lighting in Steel Passenger Cars, H. A. **Currie**, assistant electrical engineer, New York Central & Hudson River Railroad.

Provision for Electrical Equipment on Steel Motor Cars, F. W. **Butt**, assistant engineer, New York Central & Hudson River Railroad.

Air Brakes for Heavy Steel Passenger Cars, A. L. **Humphrey**, vice-president and general manager, West Traction Brake Company.

Cast-Steel Double Body Bolster, Platforms and End Frames for Steel Cars, C. T. **Westlake**, chief mechanical engineer, Commonwealth Steel Company.

Special Ends for Steel Passenger Cars, H. M. **Estabrook**, president, Barney & Smith Car Company.

Special Pressed Steel Shapes for Steel Cars, J. M. **Hansen**, president, Standard Steel Car Company.

ORGANIZATION MEETING IN MINNEAPOLIS

A movement for organization of members of the Society in Minneapolis was set on foot at a large dinner at the Hotel Radisson on March 18, attended by over a hundred engineers from various parts of Minnesota. As a result of the meeting, it is proposed to establish a local headquarters for the members of the engineering profession in Minneapolis, with a free public reference library of engineering.

The meeting was presided over by Paul Doty of St. Paul, who introduced the Secretary of the Society, Calvin W. Rice, who had come on from New York especially to attend the dinner. Mr. Rice told of similar work being done in New York, Boston and St. Louis, and assured the members that its accomplishment in Minneapolis was only a question of time and would mean much benefit not only to the profession but to the community. He particularly emphasized the importance of all pulling together.

Mr. Rice was followed by Prof. J. J. Flather of the University of Minnesota, who spoke on the University in Relation to Mechanical Engineers, and by J. L. Record, president of the Minneapolis Steel and Machine Company, on the Industries and the Mechanical Engineer. Oliver Crosby, president of the American Hoist and Derrick Company, followed with some remarks upon the Mechanical Features of the Panama Canal, with which he is familiar, and C. L. Pillsbury of Minneapolis spoke of the Mechanical Engineer in Practice. The concluding remarks of the evening were made by Max Toltz of St. Paul, chairman of the committee in charge of the dinner, and the originator of the idea of coöperation among the engineers of Minnesota.

MEMORIAL TO ALEX. L. HOLLEY

The House Committee has on exhibition in the Council Room a bronze bust of Alexander L. Holley, our honorary member in perpetuity. This study is by William Ordway Partridge of New York, and is offered for criticism in the hope that a perfect portrait in bronze may be the result, as a permanent reminder of this great engineer. It is requested that all of the members of the Society who were personally acquainted with Mr. Holley inspect this bust and send their criticisms to the Chairman of the House Committee, Edward Van Winkle, 90 West Street, New York City. It is the desire to incorporate these suggestions of the members who were intimate with Holley in a report to the sculptor so that he may be aided in the production of a perfect likeness.

We are particularly fortunate in obtaining the services of Mr. Partridge, who has executed many works for the city, state and federal governments, among them the equestrian statue of General Grant in Brooklyn, Alexander Hamilton at Columbia University, and the Hamilton and Jeffersonian statues in Washington.

MEETING IN GERMANY, 1913

The itinerary of the visit of the Society to Germany by invitation of the Verein deutscher Ingenieure and in connection with its annual meeting will be as follows:

TENTATIVE PROGRAM

NEW YORK

Tuesday, June 10

10.00 a. m. The party sails on the Hamburg-American S. S. Victoria Luise (remodeled "Deutschland") from Hoboken. It will be advisable for members of the party to reach New York not later than June 9.

Representatives of the Verein deutscher Ingenieure will come on board at Cherbourg to receive the visitors.

HAMBURG

Thursday, June 19

Arrival in Hamburg.

Friday, June 20

11.00 a. m. Address: The Hamburg Harbor
11.00 a. m. to 1.00 p. m. Trip around the harbor
5.30 p. m. Reception in the Municipal Hall by the Senate of the city and by the Hamburg Section of the Verein deutscher Ingenieure

Saturday, June 21

10.00 a. m. Excursions
- Group 1: Inspection of the Elbe tunnel and visit to the shipyards of Blohm and Voss
- Group 2: Visit to the Vulcan yards and inspection of the Elbe tunnel

Sunday, June 22

10.00 a. m. Departure for Leipzig

LEIPZIG

Sunday, June 2

4.30 p. m. Arrival in Leipzig
8.00 p. m. Reception in the Crystal Palace

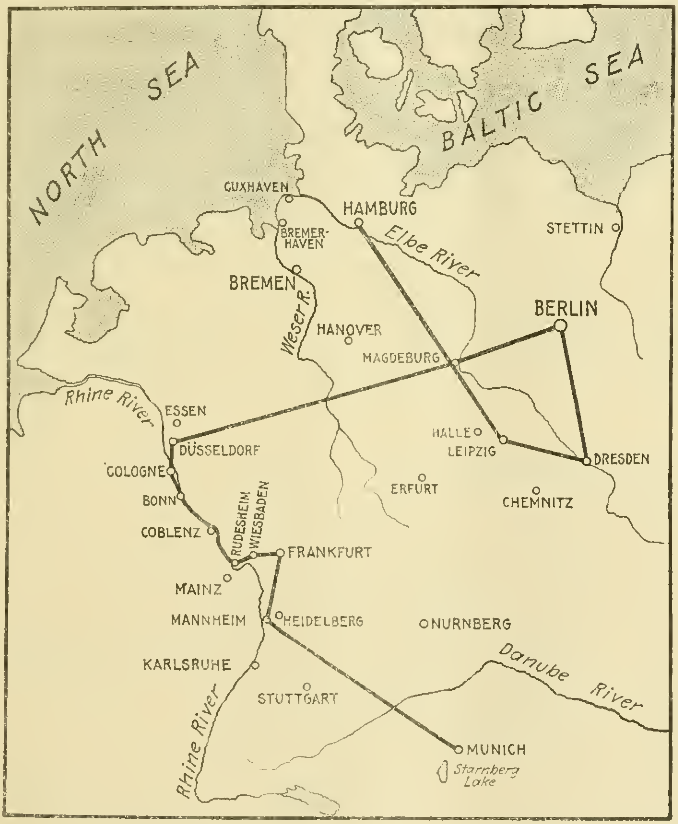
LEIPZIG

Monday, June 23

10.00 a. m. Formal meeting in the Municipal Hall

5.00 p. m. Concert under the direction of Mr. Arthur Nikisch in the Gewandhaus

7.30 p. m. Formal dinner in Central Theater



Itinerary of Official Tour in Germany

Tuesday, June 24

9.30 a. m. Scientific Lectures in the lecture room of the Architectural Exhibition

4.30 p. m. Inspection of the Monument of the Battle of Nations in commemoration of 100th anniversary of the battle of Leipzig, 1813

8.00 p. m. Festival in the Palm Garden

LEIPZIG

Wednesday, June 25

9.10 a. m. Departure for Dresden

DRESDEN

Wednesday, June 25

11.00 a. m. Arrival in Dresden

2.00 p. m. Gather at the Belvedere; automobile trip to the Saxon Switzerland (Bastei), walk to Rathen, by steamer to Pirna, by automobile to Dresden.

8.30 p. m. Reception in the Municipal Building, tendered by the city of Dresden.

Thursday, June 26

9.30 a. m. Excursion through Dresden
- Group 3: Machine Laboratory of the Technical High School
- Group 4: Seidel & Naumann Sewing Machine and Bicycle Factory
- Group 5: Picture Gallery

12.30 p. m. Lunch in the Neustadt railway terminal

2.00 p. m. Departure for Berlin

BERLIN

Thursday, June 26

5.00 p. m. Arrival in Berlin

8.00 p. m. Reception in the Reichstag Building

Friday, June 27

9.30 a. m. Excursions
- Group 6: Allgemeine-Elektricitäts Gesellschaft
- Group 7: Siemens-Schuckert Works
- Group 8: Bergmann Electrical Company
- Group 9: Ludwig Loewe Company, Machine Tool Factory
- Group 10: A. Borsig Locomotive Works in Berlin-Tegel
- Group 11: Ladies' excursion and lunch

8.00 p. m. Formal dinner in the Zoological Garden

Saturday, June 28

2.30 p. m. Automobile trip to Potsdam and steamer trip on the Havel

7.00 p. m. Entertainment by the Berlin Local Section in Wannsee

Sunday, June 29

8.00 a. m. Departure for Düsseldorf, Rhine-Westphalia

DÜSSELDORF

Sunday, June 29

6.00 p. m. Arrival in Düsseldorf

8.00 p. m. Reception in the City Hall tendered by the city of Düsseldorf

DÜSSELDORF

Monday, June 30

9.00 a. m. Excursions

Group 12: Duisburg works of the German Machine Works Company (50 participants)

Group 13: Friedrich-Alfred steel plant of the Friedr. Krupp Co. in Rheinhausen (75 participants)

Group 14: Machine Works of Thyssen & Co. in Muhlheim (Ruhr) (20 participants)

Group 15: Gutehoffnung Steel Plant, Oberhausen Rheinland (40 participants)

Group 16: Rhein Steel Works, Duisburg-Meiderich (50 participants)

Group 17: In the morning the ladies inspect the city of Düsseldorf, and in the evening the welfare activities of Friedr. Krupp Co. in Essen

Group 18: Afternoon inspection of the Duisburg-Ruhrort harbor by the members of groups 12 to 16, as well as others who apply for it

The other visitors will be afforded an opportunity to see the city of Düsseldorf

8.00 p. m. Banquet in the city concert hall of Düsseldorf tendered by the Rhine-Westphalian Section of the Verein deutscher Ingenieure

Tuesday, July 1

9.00 a. m. Excursions

Group 19: Haniel & Lueg, Düsseldorf-Grafenberg (50 participants)

Group 20: Ernst Schiess Company, Düsseldorf (50 participants)

Group 21: German Machine Works Company, Benrath plant, Benrath (50 participants)

Group 22: Steel Works of Becker Company, Willich b./Krefeld (75 participants)

Group 23: Trip into the mountains; inspection of the Elberfeld Lift railway, Barmer mountain railway, steel plant of Rich. Lindeberg Company, Remscheid-Hasten and the Mungsten Bridge

Group 24: The ladies will inspect some installations in the city of Düsseldorf

4.30 p. m. Departure for Cologne. Members of Group 23 go from Remscheid direct to Cologne

COLOGNE

Tuesday, July 1

5.30 p. m. Arrival in Cologne

8.00 p. m. Informal gathering in the Zoological Garden of Cologne tendered by the Rhine-Westfalen Board. Trip on the Rhine with illumination of the city and cathedral

COLOGNE

Wednesday, July 2

9.00 a. m. Excursions
- Group 25: Dye Works, formerly Friedr. Bayer & Co. Leverkusen (up to 100 participants)
- Group 26: Gas Engine Works, Deutz, Cologne-Deutz (up to 100 participants)
- Group 27: Machine Works Humboldt, Cologne-Kalk (up to 100 participants)
- Group 28: The ladies inspect the cathedral and city

8.00 p. m. Reception in Gurzenich tendered by the city of Cologne

Thursday, July 3

8.00 a. m. Departure by rail for Coblenz; thence on the Rhine by steamer to Rüdesheim, where there will be a festival on the banks, and thence by rail to Frankfort-on-Main

FRANKFORT-ON-MAIN

Thursday, July 3

6.00 p. m. Arrival in Frankfort-on-Main

8.00 p. m. Reception in the Palm Garden by the Frankfort Section of the Verein deutscher Ingenieure

Friday, July 4

11.30 a. m. Welcome by the city in Roemer. Luncheon

2.30 p. m. Excursions
- Group 29: Eastern port and gas works
- Group 30: Stockyards and gasholders
- Group 31: Refuse destroyer plant and filters
- Group 32: Inspection of the old city, Goethe house, Historical Museum
- Group 33: Visit to Saalburg

7.30 p. m. Independence Day celebration with the American colony

Saturday, July 5

10.30 a. m. Departure for Mannheim

MANNHEIM

Saturday, July 5

12.00 m. Arrival; lunch in the Friedrichspark

Excursions
- Group 34: Machine Works, Heinrich Lanz
- Group 35: Machine Works, Sulzer Bros. in Ludwigshafen
- Group 36: Brown-Boveri & Co., electric machinery
- Group 37: Cement Works in Leinen and their welfare activities

Group 38: Benz & Co. Rhine Automobile and Motor Works Company
Group 39: Inspection of the port (steam flour mills in Ludwigshafen)
8.00 p. m. Reception of welcome

Sunday, July 6

11.00 a. m. Departure for Heidelberg

HEIDELBERG

Sunday, July 6

12.00 m. Arrival; lunch in the Stadtgarten, inspection of the Castle, concert in the Castle Restaurant
6.00 p. m. Dinner on the Molkenkur tendered by the Board of Reception
10.00 p. m. Trip to the Castle, illuminated by fireworks, given by the City of Heidelberg
11.00 p. m. Return to Mannheim

MANNHEIM

Monday, July 7

10.00 a. m. Departure for Munich

MUNICH

Monday, July 7

5.00 p. m. Arrival in Munich
8.00 p. m. Reception of welcome in the Hofbrauhaus

Tuesday, July 8

9.30 a. m. Inspection of the German Museum and its new building
3.00 p. m. Trip to the Sternberger See
8.00 p. m. Concluding exercises in the Rathhaus

So large a proportion of the membership and their friends have expressed a desire to participate in this trip, that reservations are now practically closed, and a waiting list of ladies has already become necessary. Any vacancies which may occur in the party will be filled by subsequent requests, in the order of their receipt.

Circulars containing complete information as to the details of the trip have been issued to those who will participate, and any further data may be secured from the headquarters of the Society. The Verein deutscher Ingenieure is preparing for the use of all participants a detailed guide-book for the trip, containing a general description of the cities to be visited and of all the industrial establishments included in the tour.

DEATH OF SIR WILLIAM ARROL

Two factors will always be found in any engineering structure of magnitude. The first is the scientific or design factor supplied by knowledge of physical law. The second is the craftsmanship, or the experience and skill evidenced in embodying the design in material form. The first requirement is for technical knowledge and experience. The second calls for knowledge of men, experience, credit and administrative capacity. In the United States the economic trend has been in the direction of meeting the need of the hour by means of standard constructions. The design and the engineering skill are both supplied by the constructor from within his organization and the constructor as contractor supplies the finished work to the user. This makes for economy in many directions. The British system has been to have the design and the engineering skill and responsibility furnished by one party who will usually be called a consulting engineer, and the craftsmanship and execution of the work confided to some one entirely different. The consulting engineer sees only that his design is properly carried out. The skill and economies of the process of construction and erection are confided to the contractor. The latter makes the money if there is any profit to be made.

Sir William Arrol and the Dalmarnock Works near Glasgow, Scotland, furnish a noteworthy example of the best application of the British principle. Sir William owed his advancement to his splendid ability and courage in the attack of big problems, and his success financially to his attacking these problems in a large way, and applying machinery on a large scale to effecting economies in construction. His engineering office was not engaged on problems of outside design. It was directed to the making of the details which were required to produce economically and effectively the material and the erection of the designs of others.

He was born in 1839. His father was a Scotch cotton spinner and rose to become manager of the great Coats Thread Works of Paisley. William entered the works under his father's management as a boy in the woodworking shop, but at the age of fourteen he evidenced his preference for metal working and he entered the blacksmith shop of Mr. Thomas Reid. An apprenticeship lasted four years in those days and during a period of six years thereafter he traveled as journeyman in various parts of Scotland and England. At twenty-four he became foreman of the bridge and boiler departments of the works of Laidlaw & Sons, remaining with them for five years. In 1868, or when he was twenty-nine years of age, he invested his savings of 85 pounds sterling in a little plant in the outskirts of Glasgow for machinery repairing, boilermaking and general blacksmithing. More than one-half his capital went into the engine and boiler alone. Business must have come to the young energy and enthusiasm of the little shop, for extensions became necessary and it was in 1871 that the Dalmarnock Works were begun with about thirty men. The ability and capacity which have come with opportunity developed that modest beginning into the plant of today, covering some twenty acres and employing when in full operation about 5000 men.

The foundation of his fame as a bridge builder and constructor was early laid by a long multiple-span bridge for the Caledonian Railway across the Clyde. He introduced in these bridges what was at that time the entirely novel method of erection on the ground, constructing the span without false work and rolling each girder out over the piers until it could be dropped into position. This method attracted the attention of all the engineers and work immediately began to flow in. The viaduct over the Clyde at Glasgow gave opportunity for his design and application of multiple drilling in the field and the hydraulic riveter. This was in 1875.

It will be recalled that in 1879 England experienced one of its great engineering disasters in the wreckage of the bridge over the Tay. The bridge had to be re-erected and Mr. W. H. Barlow was entrusted with the work and made Mr. Arrol his contractor. The rebuilding of the bridge took five years and was completed in 1887 with 74 spans and a total length of 10,700 feet. It has withstood all attacks from the tempestuous gales from the North Sea to which it is exposed. The success of this undertaking led Sir John Fowler and Mr. Benjamin Baker in coöperation with Mr. Arrol to undertake the great cantilever to cross the Firth of Forth. Tunnels and suspension designs were carefully investigated, but while a cantilever principle was decided upon as the most feasible, the dimensions were far in excess of anything that had been attempted before. The two main spans are 1710 feet long with a headway below the center span of 150 feet above the water. The towers are a little above 360 feet high. The scale of the work to be done called again for special plant and the value of the investment on the ground has been estimated at over a million dollars. It was at this time that Mr. Arrol produced an oil fired furnace for heating rivets and greatly improved the hydraulic riveting machines. It was at the Forth Bridge that Mr. Arrol invented what has been called the hydraulic spade to work in the resistant boulder clay into which the caissons had to be forced. Queen Victoria conferred the honor of knighthood on the successful contractor on the opening of the bridge in 1890 and in that same year he received the honorary degree of LL.D. from the University of Glasgow. The Forth Bridge was still building when the contract came for the steel work of the Tower Bridge of London with its 200 feet clear opening and its lifting bascules of 1200 tons each. In addition Sir William's firm did a great deal of viaduct and swing bridge work for the Manchester Ship Canal, for bridges over the Nile at Cairo, for a bridge with the widest span in England over the Wear at Sunderland, and elsewhere both in England and in the colonies. The organization of the Dalmarnock Works was made into a limited liability company in 1895 and the building of steel factory and railway structures was made a part of the business. Sir William was a great believer in abundance of light as a factor in successive and rapid production, and favored the modern steel glass roof construction.

Fame came to him in other directions and he sat in Parliament from 1895-1906. He was not a talker but was much relied upon by his colleagues for his sound advice in industrial legislation in committees. He was a Fellow of the Royal Society of Edinburgh and other scientific and philanthropical organizations. The Institution of Engineers and Shipbuilders in Scotland honored him with its Presidency in 1895 and in that same year The American Society of Mechanical Engineers elected him an Honorary Member. The letter which started that movement in the Society was signed by Mr. Andrew Carnegie, who had long admired the man and his methods.

His personal character was one of rare charm, sympathetic, tactful, warm-hearted and generous. His capacity for attention to detail was renowned and his energy phenomenal. He died after several weeks' illness from an attack of influenza on February 20, 1913.

DISCUSSION ON REPORT OF THE COMMITTEE ON STANDARD CROSS-SECTIONS AND SYMBOLS

A. A. **Adler** said that he felt there was no demand for standard cross-sections and saw no advantage in them. To show how cumbersome the system is it will be observed that nickel, chrome and vanadium steels are marked in addition to their characteristic cross-sectioning. This is due to the limited number of combinations that may be formed by the variety of lines used.

A much more serious objection is found in the burden that such a set of standards would impose upon the memory. In order to insure that the workman would use the intended materials, a legend would have to be employed to describe the meaning of the standards. This appears contrary to logical procedure. The present method of specifying the material in a "material list" is by far the most convenient method, as it also includes heat treatment and such other data as are necessary for accurate description.

There is, however, one possible use for such standard cross-sections as, for instance, where a change of section indicates a change of material. But in this case no standards of any kind seem necessary.

J. H. **Norris** said that in his practise he had used about 12 different compositions of what is listed in the report (Fig. 1) as "copper, brass or composition." He had for years sectionalized simply with a plain line, and then marking the materials, although this latter was not usually done, but was indicated on the material list accompanying the drawings. Then if the material is changed, the drawing does not have to be corrected but simply the list. The list of standards proposed seemed to him to be unnecessary.

Presented at the Annual Meeting 1912, of The American Society of Mechanical Engineers. This report appears in The Journal for December 1912.

A. E. Norton thought that Professor Adler had misinterpreted Fig. 2 in respect to the use of printed labels to indicate chrome steel, nickel steel and other variations of chemical composition.

Such labeling is entirely optional, the hatching lines being used only to indicate the process of manufacture, that is, whether the steel is a casting or a forging.

F. De R. Furman, speaking as a member of the committee, said that the putting out of these specifications for the representation of different materials had been induced by the fact that a number of different standards are in use in different drafting rooms. It seemed a desirable thing to secure coöperation between the drafting rooms, which already used a special kind of cross-section line, and have them adopt a uniform standard, to avoid confusion.

Spencer Miller regarded the plan as valuable since it allows of the adoption of as many or as few of these standards as may be desired in any drawing room. If any plan is to be adopted at all by a drafting room, it would seem better to adopt one which others have agreed to.

L. P. Alford and Arthur L. Ormay.[1] The authors of this discussion are firm believers in the principle of engineering standardization and its application to engineering work. Thus when the report of the Committee on Standard Cross-sections and Symbols was published, they at once turned to it with the purpose of adopting the standards there recommended in their own work. Careful study, however, led to the conclusion that it was impractical to make use of the material thus presented, for a number of reasons, and further consideration led to the preparation of this discussion.

The most serious objection is incompleteness. There are no symbols for a large number of the materials frequently used in mechanical engineering and represented on drawings of members of this Society. Other objections are, a failure to use lines of uniform direction, the sacrifice of individuality in the symbols to a uniform weight of line, and finally an apparent failure to consider the practise and standardization work of others. Further, the general scheme of classification is open to a difference of opinion, for another viewpoint has been taken in the cross-sections and symbols accompanying this discussion.

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[1] Chief draftsman, Hill Publishing Co., New York.

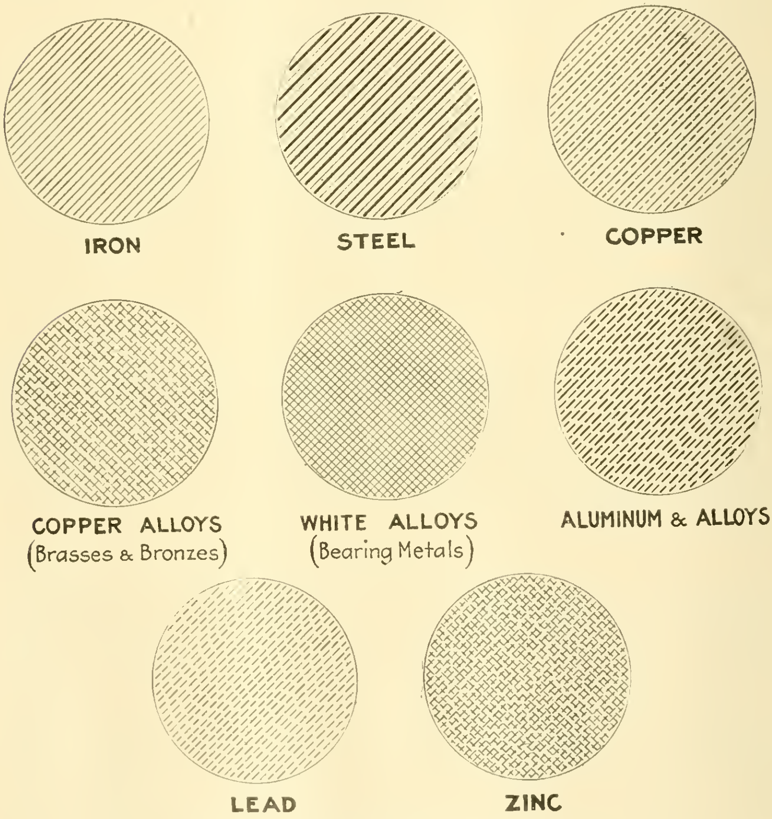
IRON
STEEL
COPPER
COPPER ALLOYS (Brasses & Bronzes)
WHITE ALLOYS (Bearing Metals)
ALUMINUM & ALLOYS
LEAD
ZINC

Fig. 3 Cross-Sections for Metals

The Symbols Suggested. The meaning of these objections can best be seen by turning to the symbols shown in Figs. 3-6, which are offered by way of suggestion. There are four groups: cross-sections for metals (Fig. 3), symbols for building materials (Fig. 4), symbols for geologic formations (Fig. 5), and symbols for miscellaneous materials (Fig. 6).

In all of these cross-sections and symbols having ruled lines, the direction of the lines is standardized to two, horizontal and inclined at an angle of 45 deg. with the horizontal. In addition to these the committee's report includes inclined lines, at an angle of 30 deg. with the horizontal, as seen in the symbol for babbitt or white metal.

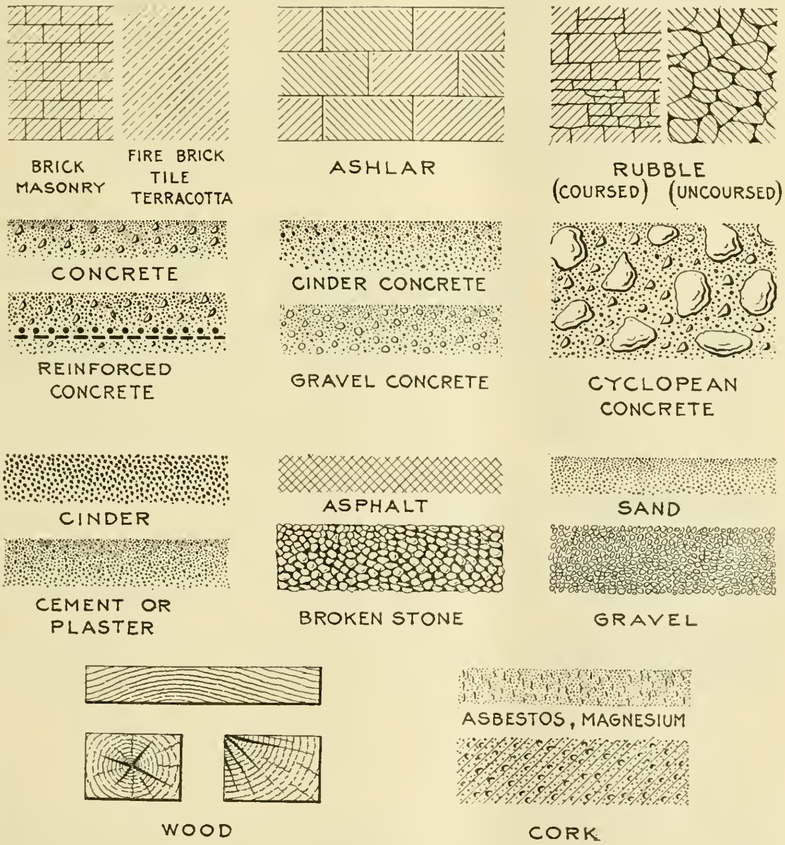

Fig. 4 Symbols for Building Materials

Four weights of line are used. The committee's report standardized this feature to a single one. This is a simplification of practise at the expense of result. To the authors' minds such a course is unjustifiable. The quality of the results can be judged by referring to the cross-sections for wrought iron, cast steel and wrought steel in the committee's report. From the casual glance of a person familiar with reading drawings, there is but little difference between these cross-sections, not enough to individualize any one of them. In fact, these are so similar that it is doubtful if draftsmen would readily remember them and their differences.

As a detail in the method of presenting these suggested cross-sections and symbols, a difference in form has been made for different materials. This is intended to have some reference to the shape in which the material is met with or used in engineering work. That is, the metal cross-sections are presented by a circular cross-hatched area which might represent the end of a bar, or rod. Earth and rock are shown by an irregular outline that might be part of a section of a bank or ledge. This same idea has been carried out in connection with some of the others.

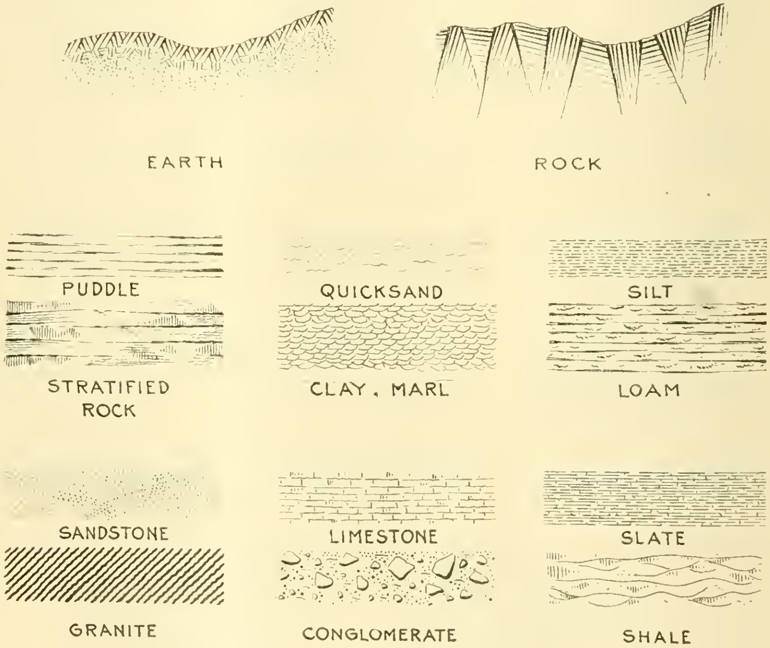

Fig. 5 Symbols for Geologic Formations

The general scheme followed in developing this series has been to distinguish between families of materials by cross-sections and symbols easily remembered, and then make use of abbreviations or names to distinguish subdivisions of these groups. This group system is best illustrated by the cross-sections for metals and the symbols for concrete.

Cross-Sections for Metals. The metals group has eight cross-sections (Fig. 3); of these, five are family groups. The iron group includes cast iron, malleable iron, wrought iron, ingot iron and perhaps others. The steel group includes tool and cast steel, high-speed steel, crucible and high-carbon steel, alloy steels, as nickel, manganese, chrome nickel, vanadium, and the ordinary steels of machinery construction, such as bessemer, cold rolled, open hearth, machinery, cold drawn and low carbon. The copper

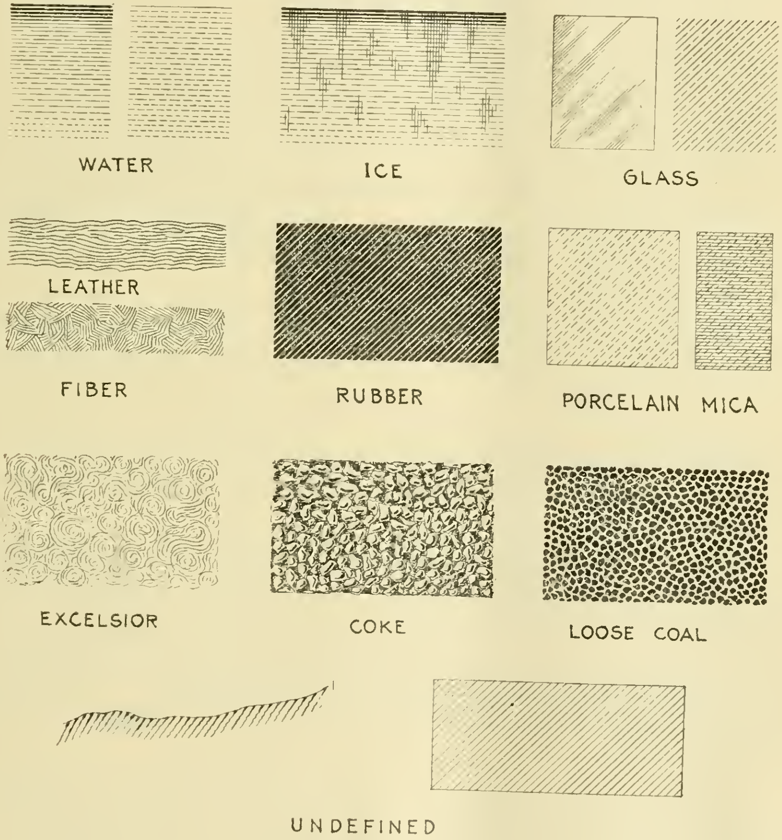

Fig. 6 Symbols for Miscellaneous Materials

alloys include brasses and bronzes in all their variety; white alloys include babbitt and all kinds of white metals; and the aluminum group aluminum and its alloys. The other three symbols are for copper, lead and zinc, respectively. It should be noted that the copper alloy cross-section is a combination of the copper and lead rulings.

It is believed that these cross-sections cover all of the important families and ordinary engineering metals that are used unalloyed. In practise, the symbol for iron would ordinarily be applied to cast iron, and if any of the other kinds were to be specified its abbreviation or name would be printed across the section. Similarly the steel cross-section would be taken to mean a low-carbon machinery steel and the other grades indicated by abbreviations or names. This same method could be applied to the copper alloys.

Symbols for Building Materials. But little comment need be given to the 19 symbols for building materials (Fig. 4), except that those presented are believed to cover the ordinary materials met with in the work of members of this Society. Attention is called to the symbol for ashlar, which is believed to represent this important material better than the one shown in the committee's report.

Symbols for Geologic Formation. Here are 14 symbols (Fig. 5), which are believed to cover the formations ordinarily met by members of this Society in connection with foundations for buildings, dams, and other engineering structures. In general, they follow the symbols prepared and published by the United States Geological Survey, and thus have the advantage of being already in use.

Symbols for Miscellaneous Materials. The symbols for miscellaneous materials (Fig. 6) are 11 in number. Some of these may seem new, but all have found use in the work of the authors. The reason for most of them is apparent. By way of explanation, excelsior, coke and coal are represented on power plant drawings, in cross-sections of boilers, coal pockets, gas producers and gas scrubbers, as the case may be.

The final symbol on this chart is for undefined or unclassified material, and follows the suggestion contained in the committee's report.

In conclusion, the authors have written this discussion with a single motive, that of aiding in the constructive work of preparing a series of cross-sections and symbols adequate to the entire field of the work of the mechanical engineer and arranged in a form to be adopted and used. It is hoped that the report which has been discussed will be considered merely as preliminary and that further consideration will be given to this important subject.

In connection with further work, two suggestions are in order. The first is the preparation of a series of abbreviations of the names of the materials forming the subdivisions of the general groups. The second is much broader and is to make a complete study of drawing-room conventions. The modern conception of mechanical drawing is that it is an engineering language. Though this characterization is true, it is a language without uniformity, without grammar, and filled with dialect and peculiarities of expression. A careful investigation of mechanical drawing conventions, with a report putting them in comprehensive form, would be of great value to the members of this Society and to our engineering colleges.

O. K. Harlan wrote that for the cross-sectioning for wrought iron he would prefer a light and heavy line in pairs, similar to that for cast steel but having one of the two light lines made heavier. This has been used for many years and he believed to be now in quite general use. It gives a clearer distinction between wrought iron and steel than the sections shown in the report, and can be made with the same number of strokes of the pen by retracing one of the two light lines and making it twice as heavy. The sections shown in the report require a second glance to tell which is which, wrought iron or steel, since they are so nearly alike.

The sectioning for rubber did not seem to him to be the best obtainable. Insulation as used in electrical work often involves small pieces, and to use the sectioning shown would admit of confusion between the section lines and the actual lines of the mechanism. In some cases he had used solid black, as rivet holes are sometimes shown in structural steel work, and he had also used soft black pencil on the tracing, which gives an effect on the print which is easily distinguishable. By lettering hard rubber, fiber, vulcanite, etc., in ink on the tracing, it shows clearly on the print and seems to cause less confusion than the light horizontal lines recommended by the committee. He was not disposed, however, to urge the use as standard of either the black pencil or solid black ink.

The Authors. Referring to the suggestion of using lines of more than one thickness, the committee have reached the conclusion, after careful consideration, that lines of uniform thickness will not only facilitate the drawing of cross-sections, but will save much time in waiting for heavy ink lines to dry. If draftsmen had always been in the habit of using lines of uniform thickness in cross-section work, the committee doubt very much if they would now adopt sections made of lines having variable weights.

The underlying principle of the standard sections recommended is the use of single lines for cast iron, then the wrought and forged irons are indicated by making every alternate line double. In a similar way cast steel is shown by double lines in pairs and all the wrought and forged steels by adding an additional line to each alternate pair.

The committee have avoided the use of dotted lines in all cross-section work, except when such lines are used in combination with solid lines, thus preventing confusion with dotted lines which represent objects behind the plane of section.

It is true that frequently rubber and insulation materials are shown in solid black. When these sections are narrow there is no objection to this practise, but when the sections are wide, heavy patches of ink tend to crumple the tracing cloth or paper, and in such cases the section recommended by the committee would be clearer and not liable to confusion.

In cross-sections showing babbitt or white metal, which usually occur in narrow widths, the committee recommend the use of a 30-60 deg. line because it facilitates the act of drawing by requiring a fewer number of lines.

The committee believe it would not be wise to attempt to formulate a standard for every material.

Symbols for various building materials; symbols for geologic formations and symbols for miscellaneous materials, the committee believe, are best worked out by subdividing one of the standard cross-sections as recommended, according to the scheme reported on by the committee under typical subdivisions. Such subdivisions are chiefly used by specific trades or by those working along particular lines. The committee see no objection to the use of many of the symbols submitted by Mr. L. P. Alford and Mr. Arthur L. Ormay, but believe that they should be classified under typical subdivisions, rather than included as standard cross-sections or symbols.

COST OF UPKEEP OF HORSE-DRAWN VEHICLES AGAINST ELECTRIC VEHICLES

By W. R. Metz

ABSTRACT OF PAPER

A great deal has been written on the subject of motor trucks versus horse-drawn vehicles, but it appears to be extremely difficult to obtain exact figures, as most firms regard the item of hauling as an overhead expense not worthy of the minute examination given to the other departments.

The motor-driven vehicle is unquestionably cheaper to operate than is the horse drawn vehicle where a number of vehicles are used, and, in the opinion of the writer, the only question to be determined is the advisability of using electric or gasolene-driven machines. From figures on hand, it appears that the cost of upkeep of the gasolene-driven machines is about double per mile that of the electric-driven machines (not including driver's or helper's wages), but, on the other hand, the gasolene-driven machines have a much larger radius of operation and, in certain cases, this would more than offset the cheaper upkeep expense of the electric-driven machine.

As a general proposition, it appears that the electric-driven machine is better for city service where the streets are in fairly good condition, and that the gasolene-driven machine is better for long hauls over rough roads and in the open country, mainly on account of the ability to obtain gasolene and water, and the chances of making greater speed.

COST OF UPKEEP OF HORSE-DRAWN VEHICLES AGAINST ELECTRIC VEHICLES

By W. R. Metz, Washington, D. C.

Member of the Society

During the fall of 1910 the writer and the accountant of our office were instructed to submit a report as to the desirability of purchasing motor trucks to replace horse-drawn wagons, and an investigation was made covering certain government departments and private firms. This report was submitted in November 1910, and it was estimated that the office would save approximately $11,000 per annum if electric vehicles were purchased and all of the horse-drawn equipment sold.

2 This report was approved and equipment purchased as outlined herein, and the results were most gratifying as the saving during the first year was nearly $12,000, in spite of the fact that, during this year, only a part of the electric truck equipment was purchased and six horses were kept. Five of these horses have since been sold, and the saving during the next year will undoubtedly be increased.

PRELIMINARY INVESTIGATION

3 The naval gun factory at Washington operated five electric trucks, two of which had been in operation for four years; one of these had a capacity of 2500 lb., and the other a capacity of 5 tons. The first was furnished by the McCrea Motor Company of Ohio. and the other by the Studebaker Company. The cost of operation and the saving accomplished were as given in Table 1.

5-TON ELECTRIC TRUCK

4 The cost of operating this truck was about the same as the

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

TABLE 1 2500-LB. ELECTRIC TRUCK

Cost of Truck	$2230.00		
Labor for charging batteries		$46.44	
Charging		16.50	
Acid		18.00	
Rubber jars		15.00	
Batteries (partly renewed)		64.98	
Carbon brushes		1.80	
Repairs		99.96	
1 Operator at $2.48 per day		776.24	
2 Laborers at $1.92 per day each		1201.92	
Totals	$2230.00	$2240.84	
Depreciation 10 per cent		223.00	
Interest on investment at 2 per cent		44.60	
Total cost			$2508.44
Total Mileage per Year	3366		
Cost per mile	$0.745		
This truck displaced 5 horses and carts, costing as follows:			
5 Carts by contract at $1.92 per day		$3004.80	
5 Laborers at $1.92 per day each		3004.80	
Total		$6009.60	
Net Saving of Truck over Horses per Year =	$3501.16		

2500-lb. wagon, excepting that the 2500-lb. wagon cost 75 cents for charging per 40 mile radius while the 5-ton truck cost $1.10 for the same radius. The total cost of operation is given as $2396.84, and if depreciation and interest on the investment of $3725 are included the total cost will be $2843.84.

5 This truck displaced two 2-horse wagons costing as follows:

3 Laborers, each wagon, at $1.92 per day		$3605.76
Stabling, shoeing, etc., 4 horses at $4 per day		1252.00
Total		$4857.76
Net Saving of Truck over Horses	$2460.92	

In this case depreciation and interest are not included as the original cost of the horses was not known.

6 One large company operates a number of horse-drawn wagons, also a number of motor trucks, both electric and gasolene driven. Their experience is given in Table 2.

TABLE 2 HORSE-DRAWN VEHICLES

Investment		
1 Horse	$250.00	
1 Vehicle	125.00	
Harness	30.00	
Total	$405.00	
Maintenance and Upkeep		
Depreciation		
Horse at 20 per cent	$50.00	
Vehicle at 15 per cent	18.75	
Harness at 15 per cent	4.50	
Interest on $405 at 6 per cent	24.30	
Total		$97.55
Horse Upkeep		
Feed at 47.4 cents × 365 days	$173.01	
Shoeing at 7.5 cents × 365 days	27.38	
Veterinary at 1.1 cents × 365 days	4.02	
Total		204.41
Vehicle Expense at 43.4 cents per day	$158.35	
Harness Expense	4.50	
Total		162.85
Total Expense exclusive of Labor and Stable		$464.81

7 From Table 2 can be estimated the yearly expense of vehicles requiring more than one horse, by adding the items for horses and harness to the one-horse vehicle costs as follows:

1-Horse vehicle expense	$464.81
Vehicle and 2 horses expense $464.81 plus $275.71	740.52
Vehicle and 3 horses expense $740.52 plus $275.71	1016.23
Vehicle and 4 horses expense $1016.23 plus $275.71	1291.94

These costs do not include labor and stable expense.

8 In Table 3 are given the costs of operation for the electric trucks used by this same company. Table 4 compares the operation costs of the first two trucks recorded in Table 3 on the basis of 300 days' service per year. Table 5 makes a similar comparison of the commercial and individual gasolene machines assuming 300 days' service per year for the former and 365 days for the latter. The following makes of gasolene cars were in use: Cadillac, Brush, Buick, Ford, Franklin and Maxwell, ranging from 10 h.p. to 30 h.p.

9 In addition to the records obtained from this company, the

TABLE 3 EXPENSE OF OPERATING ELECTRIC COMMERCIAL VEHICLES

Capacity, Lb.	850–1000	1500–2000	2500–3000	4000	7000
Interest and Depreciation (Machine less Batteries and Tires)............	$244.50	$306.30	$391.40	$422.94	$170.84
Mechanical and Electrical Upkeep..............	67.54	81.15	101.70	110.96	121.42
Tire Repairs and Renewals....................	79.28	97.30	155.05	267.60	535.25
Battery Repairs, Cleaning and Renewals..........	130.50	175.36	219.34	271.54	312.84
Current at 1 cent per kw-hr....................	20.00	30.20	40.00	60.00	51.50
Totals....	$541.82	$693.31	$907.49	$1133.04	$1491.85

TABLE 4 TOTAL MILEAGE OF THE FIRST TWO CARS, AND THE COST PER MILE OF EACH, EXCLUSIVE OF INTEREST AND DEPRECIATION

Capacity, Lb.	Miles per Day	Miles per Year	Cost per Year	Cost per Mile
850 to 1000	25	7500	$297.32	$0.04
1500 to 2000	25	9125	$277.01	$0.03

TABLE 5 COST AND MILEAGE OF COMMERCIAL AND INDIVIDUAL MACHINES

Service	Miles per Day	Miles per Year	Total Cost per Year	Cost per Mile
Commercial	22.2	6660	$896.69	$0.135
Individual	19.7	7190	809.53	0.1125

TABLE 6 COMPARATIVE EXPENSE OF OPERATING MOTOR VEHICLES IN PLACE OF HORSE-DRAWN VEHICLES

Vehicles for Emergency Work		
Two 2-horse vehicles at $740.52	$1481.04	
One 3-horse vehicle at $1016.23	1016.23	
		$2497.27
One 1000-lb. automobile	$1133.54	
One 2500-lb. automobile	907.49	
		$2040.53
Annual Saving by Use of Automobiles, not including Labor		$456.74
Supply Wagon		
One 4-mule wagon	$1291.94	
One 4000-lb. automobile	1133.04	
Annual Saving		$158.90
Paymaster's Money Wagon		
One 2-horse vehicle	$740.52	
One 850 to 1000-lb. vehicle	541.82	
Annual Saving		$198.70

attempt was made to secure data from a number of private firms, but unfortunately none of them had any exact figures and could only approximate the savings due to the use of both electric and gasolene-driven trucks over horse-drawn vehicles.

VEHICLES IN USE BY OUR OFFICE

10 During the fiscal year 1910 and 1911, which were the last two years that horse-drawn vehicles were used exclusively, the total expenses for the stable were $31,113.58 for 1910, and $31,231.93 for 1911; and for the same years the cost of the delivery section was $17,093.93 for 1910, and $17,256.19 for 1911, making a total cost for the delivery and stable sections of $48,207.51 for 1910, and $48,488.12 for 1911. It should be stated here that the stable and delivery sections were entirely separate at this time, each being in charge of a foreman, whereas after the automobiles were used these sections were combined, although the costs were separated.

11 The equipment, number of men employed, and the expenses of the stable and delivery sections during the fiscal year 1910 are given in Table 7.

12 Omitting the wages paid the drivers and messengers, the stable section alone cost $18,447.37, making the cost per horse per year $802.06, or $2.20 per day, of which 37¾ cents was for feed.

TABLE 7 EQUIPMENT. NUMBER AND CLASS OF MEN EMPLOYED, AND COST OF OPERATION, MAINTENANCE AND REPAIR FOR HORSE-DRAWN VEHICLES FOR YEAR ENDING JUNE 30, 1910

Equipment	Cost
23 Horses (average per year)	$6,900.00
Harness, blankets, etc.	1,350.00
1 Five-ton truck (2 horse)	425.00
7 Large delivery wagons (2 horse at $475.00 average)	3,325.00
6 Single delivery wagons (1 horse at $275.00 average)	1,650.00
3 Light mail wagons at $200	600.00
4 Depot wagons (carriages) at $300	1,200.00
2 Coupes, with pole and shafts, at $540	1,080.00
Total	$16,530.00

Number and Class of Men Employed

STABLE SECTION

1 Foreman at $2000 per year
1 Mail carrier at $3.20 per day
1 Messenger at $2.40 per day
11 Drivers at $2.40 per day
1 Stableman in charge at $2.88 per day
8 Stablemen at $2.40 per day

DELIVERY SECTION

1 Foreman at $2000 per year
4 Helpers at $3.04, 2.80, 2.72 and 2.40 per day
12 Messengers at $2.40 per day
2 Unskilled laborers at $2.00 per day

Total employees[1] in both sections = 42.

Cost of Operation of Stable Section	
Wages of foreman and stablemen	$10,113.59
Wages of drivers	12,666.21
Rent	2,400.00
Feed	3,172.20
Supplies	959.62
Repairs to harness, wagons, etc.	626.86
Shoeing	906.60
Gas and electricity	268.50
Total Cost of Operation, Maintenance and Repair	$31,113.58
Depreciation, Horses 20%, Harness 15%, Wagons 10%	2,410.50
Interest on Investment at 2%	330.60
Total Cost including Depreciation and Interest on Investment	$33,854.68

Cost of Operation of Delivery Section	
Salaries and wages	$17,085.93
Material and supplies	8.00
Total Cost	$17,093.93

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[1] 20 per cent additional is allowed for night service.

13 From Table 7 can readily be obtained the operating cost of one 2-horse, 5000-lb. capacity wagon, and these are given in Table 8.

14 During the month of November 1911, there were purchased and put into service two 1000-lb. trucks, two 2000-lb. trucks, and two 5000-lb. trucks, all of the electric type, and at the same time 17 horses and their equipment were sold, leaving six horses, one 5-ton capacity, two-horse truck, one single-horse truck, one carriage driven by two horses, and one carriage driven by one horse.

TABLE 8 COST PER YEAR OF ONE 2-HORSE, 5000-LB. CAPACITY WAGON

Wagon Expense			
Cost of truck	$425.00		
Cost of maintenance and repair		$31.75	
Cleaning and washing		66.76	
Lubricants		1.00	
Depreciation, estimated at 10%		42.50	
Total			$142.01
Horse Expense			
Cost of two horses	$615.00		
Cost of feed		$264.33	
Cost of care (hostler)		702.60	
Cost of veterinary and office labor		250.10	
Cost of medicine		2.17	
Cost of shoeing		78.84	
Cost of blankets, nets, etc	12.22		
Rental value of space (2 horses) (based on $2400 for 22 horses)		218.00	
Depreciation, estimated at 20%		125.44	
Total			$1641.48
Harness Expense			
Cost of harness	$123.00		
Cost of maintenance		$7.68	
Depreciation, estimated at 15%		18.45	
Total			$26.13
Miscellaneous Supplies		$10.00	
Drivers' Wages		751.20	
Helpers' Wages		751.20	
Gas and Electricity		23.34	
Interest on Investment at 2%		23.50	
Total			$1559.24
Total Original Cost	$1175.22		
Total Expense for One Year			$3368.86

15 In November 1912, one additional 5000-lb. truck and an electric-driven carriage were installed, and two carriage horses and one truck horse and their equipment were sold.

16 In January 1913, one 8000-lb. capacity truck was installed, and two more truck horses and their equipment were sold.

17 The truck equipment, and the number and class of men employed for caring for the electric vehicles and the remaining horses during the year 1912 is given in Table 9.

18 During the coming year, and after the remaining six horses are sold, the four stablemen will be dispensed with and in their place there will be employed probably two helpers and one laborer at a total cost of $6.80 per day, or $2128.40, thus indicating a further reduction of $1377.20.

TABLE 9 EQUIPMENT AND NUMBER AND CLASS OF MEN NOW EMPLOYED

Equipment		
Two 1000-lb. trucks	$4,639.00	
Two 2000-lb. trucks	5,498.78	
Three 5000-lb. trucks (two in use during full year)	10,625.22	
One 8000-lb. truck (installed in January 1913)	5,509.00	
One electric-driven carriage (installed in November)	3,671.00	
Total Cost		$29,943.00
Number and Class of Men Employed		
1 Foreman at $2000 per year	$2000.00	
12 Chauffeurs at $2.40 per day each	9024.40	
3 Helpers at $3.20, $2.80 and $2.72 per day	2729.36	
10 Messengers at $2.80 (two) and $2.40 (eight) per day	7762.40	
1 Mail carrier at $3.20 per day	1001.60	
2 Messenger boys at $1.20 each per day	751.20	
1 Stableman in charge at $4.00 per day	1252.00	
3 Stablemen at $2.40 each per day	2253.60	
2 Drivers at $2.40 each per day	1502.40	
35		$28,276.96

Note—Labor charge is based on day service.

19 All of the electric trucks were purchased from the Baker Motor Vehicle Company, of Cleveland, Ohio, and the iron-clad exide storage batteries from the Electric Storage Battery Company, of Philadelphia, Pa.

20 It will be noted that there have been no tire costs during the year. This, of course, was due to the fact that none of the tires have worn out, but it should be stated that the tires on the 5000-lb. trucks

are practically worn out and, in fact, were being replaced during the month of January 1913, so that the tires on these trucks wore out after running since December 1911, or a period of 13 months. The tires on the 1000 and 2000-lb. trucks are still in fairly good condition. The tires on the 5000-lb. trucks would undoubtedly have lasted longer than they did were it not for the fact that these trucks were often loaded up to 7000 lb., making a considerably harder service than could have been anticipated by the makers.

21 The total cost of operating the combined delivery, stable, and garage during the year 1912 was as given in Table 10.

TABLE 10 SALARIES, WAGES, LEAVE OF ABSENCE, HOLIDAY AND LIABILITY PAYMENTS, MATERIAL AND SUPPLIES, REPAIRS, ETC., FOR DELIVERY, STABLE AND GARAGE, JANUARY 1, 1912 TO DECEMBER 31, 1912

Month	Salaries, Wages, Leave of Absence, Holiday and Liability Payments			Material and Supplies, Repairs, Etc.		
	Delivery	Stables	Garage	Delivery	Stables	Garage
January	$1,429.23	$523.71	$818.23	$14.75	$149.85	$223.87
February	1,330.59	465.88	822.56	2.74	127.06	224.89
March	1,345.76	487.61	828.97	2.28	189.36	240.67
April	1,245.10	484.17	891.61	13.51	76.21	197.08
May	1,378.52	543.23	1,019.64	25.55	114.27	183.87
June	1,141.73	453.61	821.78	66.96	213.18	495.99
July	1,454.96	512.77	887.06	9.40	124.35	173.57
August	1,372.38	447.99	889.27	6.00	127.84	251.64
September	1,487.09	429.50	678.68	4.34	122.55	198.60
October	1,391.65	443.33	710.59	9.94	129.54	307.26
November	1,565.02	337.95	809.68	1.35	57.76	222.40
December	1,460.70	252.00	910.13	13.95	48.81	203.41
Total	$16,602.73	$5381.75	$10,088.20	$170.77	$1480.78	$2923.25

Equipment issued January 1 to December 31, 1912 $70.00 $24,446.00

22 In Table 10 it is interesting to note that the six electric trucks, doing practically all of the work, cost only about twice as much as the six horses. As a matter of fact the six electric trucks alone did as much work as the total stable force did during the year previous, and the horse-drawn equipment simply took care of the increased work.

23 Table 11 shows in detail the cost of taking care of the electric trucks, and as the cost of the trucks of any given size is about the same, only one of each size is given.

TABLE 11 ELECTRIC VEHICLE RECORD

	1000-Lb.			2000-Lb.			5000-Lb.		
	Jan.–June	July–Dec.	Total	Jan.–June	July–Dec.	Total	Jan.–June	July–Dec.	Total
Total Miles	3013.00	3511.00	6524.00	2978.00	2864.00	5842.00	3586.00	2918.00	6504.00
Ampere Hours	8598.00	8459.00	17057.00	11019.00	9710.00	20929.00	18302.00	14096.00	32398.00
Ampere Hours per Mile	2.85	2.40	2.61	3.69	3.39	3.58	5.10	4.83	4.98
Kw-Hr. Supplied	1249.8	1303.80	2553.6	1573.6	1389.4	2963.00	2678.4	2047.8	4726.2
Cost of Current	$14.67	$16.64	$31.31	$18.58	$17.79	$36.37	$31.56	$26.28	$57.84
Battery Upkeep	......	......	......	......	......	......	......	......	......
Tire Upkeep	......	......	......	......	......	......	......	......	......
Electrical Upkeep	1.20	2.93	4.13	0.75	14.38	15.13	5.06	8.67	13.73
Mechanical Upkeep	26.80	27.68	54.48	41.34	28.41	69.75	129.62	80.10	209.72
Inspection	161.58	138.67	300.25	161.58	138.67	300.25	161.58	138.66	300.24
Totals	$204.25	$185.92	$390.17	$222.25	$199.25	$421.50	$327.82	$253.71	$581.53

24 From the given figures we can readily ascertain the cost of operating one 5000-lb. capacity electric truck as compared with one 5000-lb. capacity 2-horse wagon.

TABLE 12 COST OF OPERATING ONE 5000-LB. ELECTRIC TRUCK[1]

Cost of Truck and Equipment (including spare battery and parts)	$3745.00	
Maintenance and repair (as per statement above)		$581.53
Depreciation at 10%		374.50
Interest on investment at 2%		74.90
Chauffeur's wages at $2.40 per day		751.20
Messenger's wages at $2.40 per day		751.20
Total original cost	$3745.00	
Total expense for one year		$2533.33

The cost of two 2-horse wagons being $6737.72 (Table 7), the saving due to the use of the electric truck is $4204.39.

25 Unfortunately no mileage record of the horse-drawn vehicles was kept during the previous years, but the records show that the two-horse wagon made an average of four trips per day, and the present records show that the 5000-lb. electric trucks make an average of eight trips per day. The mileage of the electric trucks being about 24 per day, it may be assumed that the mileage of the horse-drawn trucks was about 12 per day.

26 For the sake of comparison the costs of the three sizes of electric trucks and of the two-horse wagon are given in Table 13. The average load on the 5000-lb. electric truck is 5500 lb., that on the 2000-lb. truck is 2500 lb., that on the 1000-lb. truck is 900 lb., and that on the 2-horse wagon was 4000 lb.

TABLE 13 COSTS OF ELECTRIC TRUCKS AND 2-HORSE WAGON

	2-Horse Wagon 5000 Lb. Capacity	5000-Lb. Electric Truck	2000-Lb. Electric Truck	1000-Lb. Electric Truck
Average Trips per Day	4	8	8	9
Mileage per Day, Average	12	24	20	20
Mileage per Month (Loaded Halfway)	312	624	520	520
Average Load per Trip, Lb.	4000	5500	2500	900
Total Load per Day, Lb.	16,000	44,000	20,000	8100
Tons	8	22	10	4.05
Total Load per Month, Tons of 2000 Lb.	208	572	260	105.3
Total Cost per Month	$280.74	$211.11	$187.81	$180.98
Cost per Mile	0.899	0.338	0.361	0.347
Cost per Mile (Omitting Driver's and Helper's Wages)	0.499	0.138	0.121	0.107

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[1] One of these electric trucks easily replaces two 2-horse trucks.

27 The methods of keeping the records are given as a matter of interest. The Daily Meter Record and the Daily Charging Record are made out, one for each truck, by the employees in the garage. These are turned in to the office each morning and transferred to the Electrical Vehicle Record each month. This card is printed on both sides, thus providing space for a whole year.

28 The electrical and mechanical upkeep are obtained from the regular mechanics' work slips. Every machine in the office is given a number, and all repairs made and materials used are entered on the work slip and charged against the machine number and tabulated

GOVERNMENT PRINTING OFFICE
ELECTRICAL SECTION

DAILY METER RECORD—ELECTRICAL VEHICLE

Machine No...... *Battery No*....... *Date*................................, 191

	READING OF ODOMETER	READING OF AMP. HR. METER	TIME	REMARKS
IN	....	....	....	....
OUT	....	....	....	....
DIFFERENCE ..	....	....	....	....

FORM S—450

(*Signed*)..

GOVERNMENT PRINTING OFFICE
ELECTRICAL SECTION

DAILY CHARGING RECORD—ELECTRIC VEHICLES

Battery No. ... *Date*... 191

TIME	VOLTS	AMP.	SP.GR.	TEMP.
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

FORM S—447

(*Signed*)...

in the office. In this way an accurate record is kept as to the cost of each machine.

29 Under inspection is charged the time for charging batteries,

Form S-406

GOVERNMENT PRINTING OFFICE

OFFICE SUPT. OF BUILDINGS

ELECTRICAL VEHICLE RECORD

Machine No............

MONTH	JAN.	FEB.	MAR.	APR.	MAY	JUNE
TOTAL MILES						
AMP. HRS. USED						
AMP. HRS. PER MILE						
K. W. HRS. SUPPLIED						
COST OF CURRENT						
BATTERY UPKEEP						
TIRE UPKEEP						
ELECTRICAL UPKEEP						
MECHANICAL UPKEEP						
INSPECTION						
TOTALS						

Remarks ....

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washing the trucks and similar miscellaneous work in the garage, and all of this cost is evenly distributed among all of the trucks in service.

SHADING IN MECHANICAL DRAWING

By Theodore W. Johnson

ABSTRACT OF PAPER

The object of this paper is to present a new rule for shading mechanical drawings, which comprehends the most important of the rules now used without their complexities and uncertainties and the controversies which arise from their use. The new rule is proposed with a view to reducing the art of shading to a precise and exact system in the interests of rapidity in the execution and reading of drawings and of their appearance.

SHADING IN MECHANICAL DRAWING

By Theodore W. Johnson, Annapolis, Md.

Associate Member of the Society

The rules so far advanced for shading, when carried to their logical conclusion result in too may shade lines, which cause delay both in executing the drawing and in reading it and are unsatisfactory to the eye. New rules and exceptions are required to bring theory into accord with simplified practice and to avoid the bewilderment which seems to result from the present complex rules.

2 One of the most recent and best compendiums of drawing[1] thus describes the common experience.

> It is possible by using two weights of lines, to add something to clearness and legibility of a drawing, and at the same time to give to its appearance a relief and finish very effective and desirable in some classes of work. . . . Shade lines are required on patent office drawings. . . . It is correct to use them whenever a gain in legibility and appearance is of sufficient importance to warrant the expenditure of the added time necessary. . . . The strict application of this theory (referring to a direction of light upon the object) would involve some trouble, and it is never done in practise, but the simple rule is followed of shading the lower and right hand lines of all figures.

3 So unsatisfactory is the situation that many engineers discard shading altogether as a waste of time. Properly used, shading is in many cases a great time saver. In spite of the breakdown of rules and divergence of practice, shading has a very real value. No better proof can be given than two figures taken from a standard work on mechanism. Fig. 1 is an illustration of an internal friction catch. Four catches *B* are forced by springs against an annular ring *A*. Without descriptive text one can sufficiently comprehend the geometrical shapes from the

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[1] Engineering Drawing, by Thomas E. French. 1911.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

one view. Clearly one depends on the shading for proof that the action is internal and for the shape of the springs. Had a section been drawn, time would be needed for consulting it and for carrying the information (now given by the shading) back to the principal view.

4 Fig. 2 also shows an internal ratchet mechanism. By a draftsman's error the internal ratchet wheel has been shaded as if it were an external one. Here faulty shading clearly makes the drawing harder to understand than if it had not been shaded at all. It is a simpler mechanism than Fig. 1, yet students find it more difficult to understand on account of the faulty shading.

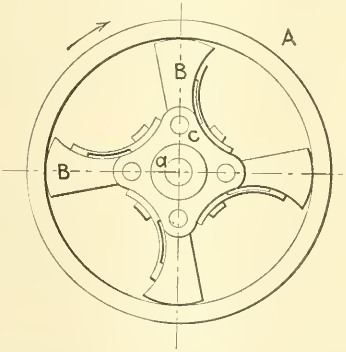

Fig. 1 Showing how Shading Aids in Reading a Drawing

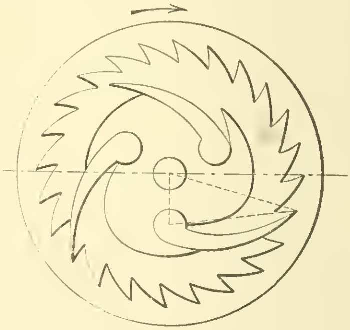

Fig. 2 Example of Faulty Shading

5 Two basic ideas have influenced shading:

i A shade line represents a shadow and as such should lie in any deep indentation of an object, or on any side far removed from the source of light.

ii A shade line marks an edge which casts a shadow. It is placed therefore on any edge which separates an illuminated surface from a dark surface.

6 The first idea is the older. The second is an endeavor to be more precise. To apply it the direction of light must be specified. With curious unanimity authorities settled upon the body diagonal of a cube placed on the drawing-board square with the paper, as shown in Fig. 3. This makes the projected direction of light a 45-deg. line on the paper, and the true direction a line raised above it at an angle of 35 deg. 16 min.

7 In applying the second rule more precise results are ob-

tained than without it, but it becomes necessary to explain and modify it by new rules.

III A projecting part does not shade a lower part. The shadows cast have no finite length. Thus in Fig. 4 the projection *a* does not, in the front elevation, prevent light from reaching the surfaces *b*, *c* and *d*.

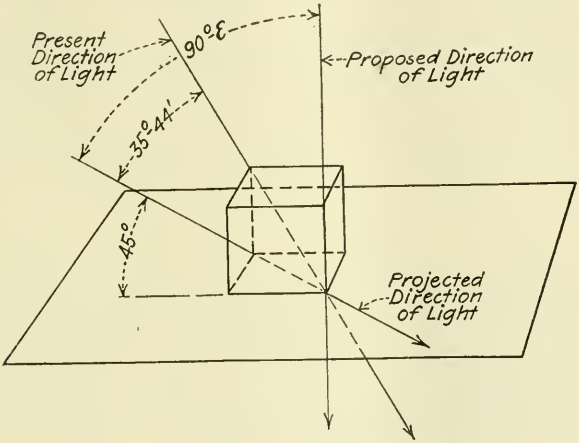
Present Direction of Light
90°-ε
Proposed Direction of Light
35°44'
45°
Projected Direction of Light

Fig 3 Direction of Light as now Used and as Proposed

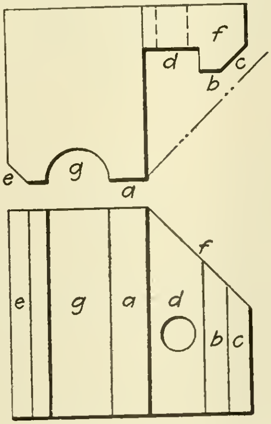

Fig. 4 Diagram to Illustrate Shading of Intersecting Surfaces

The edge of the bore hole and the right edge of the object are therefore shaded.

IV Forty-five-degree surfaces, such as *e* on the plan, Fig. 4, or *f* or *c* on the front elevation, have a tangent or skimming light and are considered as fully lighted.

8 Rules II, III and IV make a definite system which satisfies requirements, when no curved surfaces are encountered, except that they give too many shade lines. A general simplification better satisfying the eye and saving time results from a rule as follows:

> V Never make the line of intersection of two planes, of which both can be seen, a shade line.[1]

9 The results of rules I, II and V are well shown contrasted by Figs. 5, 6 and 7, representing three ways of shading a screw thread. Fig. 5 is commonest in practice; Fig. 6 is advocated by text books, but has few followers; Fig. 7 is coming into general use because it is quicker and to my mind makes a better appearance. If the threads are shaded too great prominence is given to them.

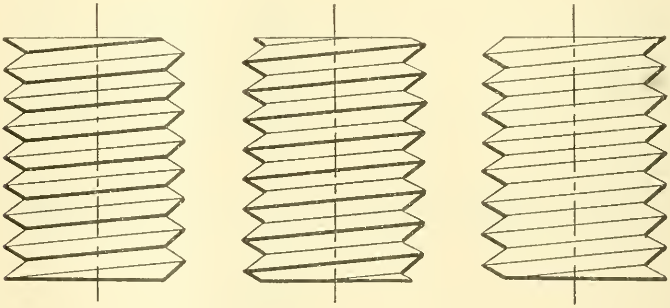

Fig. 5 Fig. 6 Fig. 7

Figs. 5, 6 and 7 Shading of Screw Threads According to Rules *a*, *b* and *c*

10 Curved surfaces intersecting each other, or intersecting plane surfaces, should be treated by substituting for them the planes which are tangent to them at the line of intersection. In Fig. 4 the edge of the hollow half cylinder *g* is shaded on the front elevation for this reason. Difficulties still arise, however, even in so simple a case as a cylinder, which should be shaded as in Fig. 8, yet no one terminates the shade line on the end of the cylinder, side view, at *a*. Also the need of a shade line on the bottom edge, *b*, is so insistent that most draftsmen shade as in Fig. 9.

11 Rule V has simplified shading and is a long step in the right direction. Ten or 15 years ago, drawings from the Bureau of

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[1] Wm. H. Thorne, Junior Course in Mechanical Drawing, 1888.

Steam Engineering of the Navy Department showed the crank arm shaded as in Fig. 10. Now they shade as in Fig. 11. Even with this rule, however, many controversial points are still unsettled.

12 So hard is it to keep five rules in mind that many authors give up the case and speak of shading by the "conventional method." "The right-hand and lower edges are made shade lines in all views." All this confusion can be swept away at one stroke. A single rule, covering or merging the five rules above, and also settling points about curved surfaces in line with the best practice, can be formulated as follows: *Shade lines mark edges which separate fully illuminated surfaces from surfaces which are quite dark, but the light upon the object comes from a point almost perpendicular to the paper, but inclined an infinitely small amount so that the projected direction of light is a 45-deg. line as at present.*

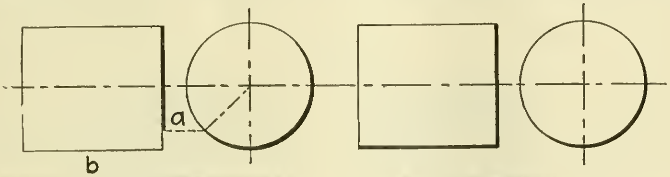

Fig. 8 Fig. 9

Figs. 8 and 9 Cylinder Shading

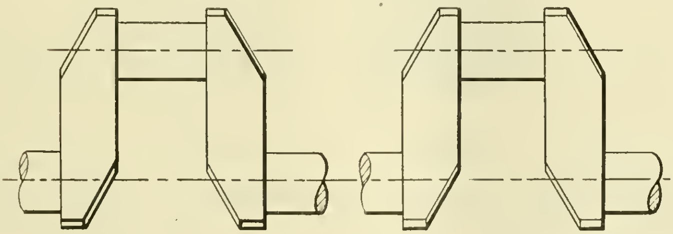

Fig. 10 Fig. 11

Figs. 10 and 11 Two Methods for Shading Crankshafts

13 Referring to Fig. 3, the result is to raise the direction of light above the projected direction, from an angle 35 deg. 16 min., at which it now stands, to nearly 90 deg. Rules I and II are now merged and become the same thing. The shadow and the edge which casts the shadow remain together. Rule III is un-

necessary. The projected length of a shadow on the drawing is necessarily infinitely short. Rule iv is covered by the new rule. Rule v is automatically observed, because no surface which is seen as a surface (not " on edge ") can be a dark surface. The " right and lower edges " of the " conventional method " can now be scientifically explained, instead of referring to examples, which at best is a case of shirking responsibility.

14 The practice of shading under this new rule will be that to which we are tending in all particulars: Fig. 4 for planes and hollow cylinders; Fig. 9 for a solid cylinder; Fig. 7 for screw threads; Fig. 11 for cylinders, cones, etc. Fig. 1 is correctly shaded and Fig. 2, with the exception of the internal ratchet wheel.

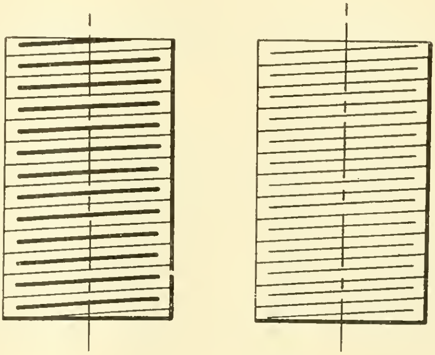
Fig. 12 Fig. 13

Figs. 12 and 13 Conventional Representation of Screw Threads

15 It may be well to mention that the conventional abbreviation of the screw thread will now be as in Fig. 13 instead of Fig. 12. Fig 12 is often used by draftsmen who otherwise do not shade at all, producing a result which is offensive to the eye. Fig. 13 is much more pleasing and there is a distinct saving in time, as it is not necessary to wait for one set of lines to dry before putting in the other, and the double handling of instruments is avoided.

16 If this rule is adopted, there will be no need for authors to write of shading. " The scientific method is universally taught and never practiced after the first blush of apprenticeship." Theory and practice will be in accord, and both will be simple.

THE PRESENT CONDITION OF THE PATENT LAW

INCLUDING RECENT AND PENDING DECISIONS OF THE SUPREME COURT OF THE UNITED STATES AND PROPOSED PATENT LEGISLATION

By Edwin J. Prindle

ABSTRACT OF PAPER

The decision of the Supreme Court in the Mimeograph case, sustaining the right of the patentee to require the purchaser of the machine to buy of the patentee ink and paper for use on it, has resulted in the introduction of a large number of bills in Congress, with a view to cutting down the patentee's monopoly. This paper explains the Mimeograph decision and, incidentally, the general nature of a patent and the monopoly which it grants, and explains the Bath Tub case recently decided by the Supreme Court; the price-restriction case of Bauer vs. O'Donnell, now before that Court for decision; the relation of the patent law to the Sherman act; and the general nature of the proposed legislation and its effect on the patent law, and upon manufacturers and inventors.

THE PRESENT CONDITION OF THE PATENT LAW

INCLUDING RECENT AND PENDING DECISIONS OF THE SUPREME COURT OF THE UNITED STATES AND PROPOSED PATENT LEGISLATION

By Edwin J. Prindle, New York City

Member of the Society

The Supreme Court of the United States on March 11, 1912, rendered a decision in the case of Henry vs. Dick which has been generally misunderstood and has aroused clamor for changes in the patent law of great public importance. The court sustained the right of a patentee to dictate conditions under which his patented machine could be used, and the same reasoning would maintain his right to fix prices below which his product could not be sold. To many laymen and some lawyers the decision seems contrary to the Sherman anti-trust act.

2 The Supreme Court has also since rendered a decision in what is known as the Bath Tub case, which bears on the relation of the patent law to the Sherman act, and tends to mark out the line between them.

3 A case known as Bauer vs. O'Donnell is now before the Supreme Court for decision on the right of the patentee to dictate the price at which his article may be sold by the retailer.

4 There is a general misunderstanding of the issues involved in Henry vs. Dick, and most men, upon hearing an adequate explanation of what the decision means, see that the rights of the public are not in any manner jeopardized by it. In consequence of this situation, and particularly of the decision in the case of Henry vs. Dick, many bills have been introduced in Congress seeking to modify the patent law in fundamental particulars, and not only to cut down the monopoly of the inventor but

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

to put his property at a great disadvantage compared with unpatented property, and the situation is a serious one. It is the object of the present paper to explain the meaning and effect of the decisions in question and of the proposed legislation.

HENRY VS. DICK

5 The case of Henry vs. Dick will be discussed first and will be treated with what might otherwise appear to be disproportionate fullness because it will be used as a basis for explaining most of the principles involved in the controversy.

6 Dick invented a mimeograph or copying machine and patented it. He sold it with this label prominently displayed on the machine:

> LICENSE RESTRICTION
>
> This machine is sold by the A. B. Dick Company with the license restriction that it may be used only with the stencil paper, ink and other supplies made by the A. B. Dick Company, Chicago, U. S. A.

7 A Miss Skou bought one of the Dick machines and Sidney Henry, the defendant in this case, sold her a can of ink, intending that the ink should be used on the Dick machine, and knowing that such use would be in violation of the notice on the machine. The Supreme Court held that Miss Skou had no right to use the machine with ink bought from any one else than the Dick company, and that Henry, in intentionally aiding her to violate her obligations to the Dick company, was a contributory infringer and was properly enjoined from a repetition of his act.

REASONS FOR ENACTING THE PATENT LAW

8 Before the patent law was enacted, the only way in which an inventor could obtain a return from his invention was by keeping it secret; otherwise a competitor might copy the invention and without any overhead expense or initial investment of capital, as compared with the inventor, reap the benefit of perhaps a large expenditure of time and money made in producing and perfecting the invention. As a result, comparatively few inventions came into existence, and those that did were jealously kept secret so far as possible. Workmen were sworn to secrecy, and the inventions were practised only under lock and key and with every effort to prevent their leaking out.

9 Under these circumstances, the public could not get the full benefit of the invention, because the inventor could not manufacture in as large quantities nor as cheaply as if it had been unnecessary to observe these precautions. If there was an ingredient or a formula or some particular step in a process which one person could take care of in the manufacturing, the inventor was likely to keep the knowledge of that one point entirely to himself, intending, usually, to disclose it to some one else when death approached, but as death often comes without warning, the inventor often died without disclosing the secret, so that the invention was lost to the world forever unless it should be rediscovered by some one else. There are not a few of these lost secrets or "lost arts."

10 When the patent law was enacted it said, in effect, to the inventor: "If you will give us (the public) a complete disclosure of your invention so that anyone skilled in the art can practise it, we will give you an absolute monoply of this invention for seventeen years. This will enable you to practise the invention without fear that it will be stolen, so that you can get the full harvest from it during the life of your patent, and we will have the benefit of it forever afterwards." The fathers of our country regarded this law as so important that they made provision for it in the Constitution itself. The first patents were granted by a board consisting of George Washington, his secretary of state and his attorney general, after a personal hearing of the inventor, and they personally signed these patents.

WHAT A PATENT GRANTS

11 The patent law simply says to the inventor: "We will give you a clear field to make money out of your invention if you can. Whether you ever make a dollar or not depends upon your own ability and industry in making, using and selling your patented invention." The patent does not cost the public one cent, for the inventor even pays all the expenses of the Government in granting the patent.

12 The patent, therefore, grants to the inventor the right to exclude or enjoin all others from any making, using or selling of his patented invention. He may either get his return by keeping the market wholly to himself and manufacturing and selling the invention, or he may sell to others immunity from

the injunctions to which the inventor is entitled by his patent. In other words, he may sell licenses or other forms of grant under his patent. which means, in effect, that " For the consideration which you pay me, I give up my right to exclude you from my monopoly to the extent we agree upon."

13 The patentee is under no obligation either to manufacture the patented invention himself or to let anyone else manufacture it. The Supreme Court has said, by a unanimous decision in the Paper Bag case, that it is the patentee's right to sit still during the life of his patent and neither manufacture himself nor let anyone else manufacture. This exclusive monopoly is the reasonable price which the public agreed to pay for the making and disclosure of the invention, and during the life of the patent it must let the invention alone. When the term of the patent has expired, the public will have an unrestricted right to use the invention of which, but for the inventor, it would never have known.

DICK'S RIGHTS UNDER HIS PATENT

14 Dick, then. was at liberty to prevent anyone from using his patented machine during the life of his patent. That would have been to exercise his *entire* right of exclusion. He did not choose to do this, however. He might have sold his machine outright for a sum of money representing the entire profit to which he thought he was entitled for his invention. If he had charged more than the public thought the machine was worth, he would have made no sales. The public would have been under no obligations to purchase the machine. Dick found that his machine did not work successfully with every kind of ink. nor with every kind of stencil paper. but that it worked much better with a certain kind of ink, and with stencil paper having certain qualities. It was to Dick's interest that the machine should do good work, in order that he might sell a large number of machines, and it was also to the interest of the public that the machines should not be disappointing to the users. Dick considered that if he only *partially* released each machine from his power of injunction, to the extent of requiring that the ink and stencil paper be bought of him, he would be able to make certain that the users of it had the right sort of ink and paper. He would also be able to sell the machine for a comparatively low price at the outset and add his profit a little at a time to the

ink and stencil paper. In this way the initial cost would not be burdensome, and the price that a person paid for a machine would be in proportion to the amount of use which he had of it; that is, in proportion to the amount of ink and stencil paper which he used upon it.

15 Another case in which the Supreme Court upheld the right of the patentee to say that his patented article should only be used under certain conditions is the Cotton Tie case, in which case the court decided that the patentee of a buckle for fastening bales of cotton could lawfully impose the condition on the purchaser that the buckle should be used only once. The patentee stamped on each buckle the words "licensed to use once only." In removing the buckle from the bale it was necessary to cut the buckle. A rival manufacturer bought the buckles after they had thus been used and cut, and repaired them and offered them for sale again. He, like Henry, in the Dick case, was restrained.

16 As Dick, under the Paper Bag decision, had the power to say to the public, "You shall not use my machine at all during the life of my patent," it was reasonable that he should have the power to say, "You may use it, but only on certain conditions," providing the purchaser agreed to those conditions at the time he purchased the machine.

17 *A sale of a patented article without conditions puts it forever beyond the control of the patentee.* It has been repeatedly decided that if an inventor once sells a machine without any conditions attached to the sale, that machine passes beyond, or without, the monopoly, and he can never again exercise any control over it whatever. It is a misunderstanding on this point that has caused much of the cry against the decision in this case. If Miss Skou had bought the machine without any license restriction on it, or without such restriction being called to her notice in any way, she could have used it with any ink she chose without interference from Dick. When she bought the machine with the license restriction displayed on it in such a way that she could not fail to notice it, she impliedly consented to the conditions of that license restriction and bought the machine subject to them. Having bought the machine with this *qualified* title to it, she could not object to Dick's wanting the bargain lived up to. The physical machine belonged to her; that is, the metal, the screws, and other parts, and she was at liberty to make any

use of them which did not infringe the monopoly granted by the patent, but she was not at liberty to trespass upon the portion of the monopoly which Dick reserved to himself when he sold her the machine; namely, the right to use that machine with other inks and other stencil papers than those made by Dick.

18 Many people think that this decision gives the patentee the right to pursue the purchaser of his patented machine and interfere with its use or sale after he has received his full pay for it, but that is not so. If he once sold the machine free from his monopoly, it would be gone forever so far as he was concerned. It is only when he sells it with the distinct understanding, either expressly agreed to by the purchaser or impliedly agreed to, because the understanding is stated in a notice fixed on the patented article so prominently that it cannot be reasonably overlooked, that he can exercise any control whatever over the patented article in the user's hands. It is not conceivable that an injunction would be granted by any court in a case where the printed notice on the patented article was not so prominently displayed as to be certain to attract the purchaser's attention.

19 Ex-President Taft, when on the bench, participated in a decision which upheld rights similar to those in the Dick machine. This related to machines for fastening buttons on shoes, the machines being sold under the license restriction that the purchaser should use them only with button fasteners bought of the manufacturers, as follows:

> CONDITIONS OF SALE
>
> **This machine is sold and purchased to use only with fasteners made by the Peninsula Novelty Company to whom the title to said machine reverts upon violation of this contract of sale.**

20 These button fasteners were not patented, and the manufacturers took their profit on the machine chiefly through charging a larger price for them than the market price. The payment for the machine was entirely inadequate, considered by itself, to compensate even for the machine. The court said that the button fasteners were, in effect, counters by which the payment for the machines were measured. This case was not appealed to the Supreme Court, but that court referred to it in a later case as a "leading case," which is a strong expression of legal approval.

21 *Henry could not have been enjoined unless he knew that his ink was to be used on the Dick machine.* The injunction was issued against Henry in this case only because he intentionally helped to bring about a violation of the rights reserved by Dick and consented to by Miss Skou under Dick's implied contract with Miss Skou. It has been repeatedly held that one who intentionally helps another to infringe a patent can be enjoined as a contributory infringer. This is precisely what Henry did. He sold the ink to Miss Skou, knowing that she was under an implied contract not to use the ink on the machine, and Henry intended that she should use it on the machine. If Henry had merely sold Miss Skou the ink, having no reason to suppose that she was going to use it in violation of a license, he would not have been an infringer and could not have been enjoined. There is absolutely no foundation for any fear that this decision would render any dealer liable to injunction who sells ink, or any other supply, without any reason to suppose it is going to be used in violation of a patent.

22 *The decision does not give Dick a monopoly of ink.* There has been fear on the part of many people that the effect of decisions like the Dick decision and the button fastener machine decision would be to give the patentee a monopoly of unpatented products; for instance, in the one case of inks, and in the other case of unpatented button fasteners. This is erroneous, however, as the public is just as free to buy ink for any other purpose than for use on the Dick machine as it ever was, and so, also, with the button fasteners. It is only when ink is bought or sold from others than Dick for the specific purpose of use with the Dick machine that Dick can interfere under his patent. It is impossible that this control over the inks to be used with Dick's machine should affect the price of ink for other purposes. Dick could not control the price of one-tenth of one per cent of all the ink sold in this country, for all of his machines together would not use that amount of ink. Whatever market for ink Dick controlled was of his own creation, by inventing the machine which uses the ink.

THE BAUER VS. O'DONNELL CASE

23 This case is closely connected in principle with the case of Henry vs. Dick. The Bauer Chemical Company manufactures

a food tonic, and sells this tonic with the following label pasted on each package:

> For sale and use at a retail price not less than one dollar ($1). Any sale in violation of this condition, or use when so sold, will constitute an infringement of our patent, under which [the tonic] is manufactured, and all persons so selling or using package or contents will be liable to injunction and damages.
>
> A purchase is an acceptance of this condition. All rights revert to the undersigned in the event of violation.

24 A Washington druggist bought the preparation from the manufacturers and sold it at a price below $1. He also bought it through jobbers and cut the price. Upon his failure to abide by promises that he would not cut the prices, the company owning the patent brought suit against him under the patent for an injunction to restrain him from cutting the price and for an accounting of profits and damages. The Court of Appeals for the District of Columbia certified this case to the Supreme Court of the United States for instructions, and the case is now awaiting a hearing by the latter court. This is the first case which has ever brought squarely to the Supreme Court the question of the patentee's right to dictate the price at which his product shall be sold, although the question is involved in a number of other suits now pending in the lower courts, and has been many times decided by the lower courts in this country and in England. The decision of the Supreme Court will, of course, settle the law on this point in the United States.

25 As explained in connection with Henry vs. Dick, the patentee really has three separate monopolies: The right to exclude all others from making, from using, and from selling his invention. These rights, with one very recent exception, have been treated by the lower courts in the United States as separate and distinct and capable of being separately sold. They have also each of them been held to be capable of sale for a limited territory, or for limited times, or limited to special trades or arts.

26 In Henry vs. Dick, the Supreme Court sustained the right of the patentee to prescribe the conditions under which his patented product should be used. In the Bauer vs. O'Donnell case, the question before the Supreme Court will be whether the patentee can prescribe conditions under which his article can be sold. The question is very important to patentees because the

whole advantage of the patent would be lost in some instances if it were not for this power over the sale of the article.

THE DICK DECISION NOT IN CONFLICT WITH THE SHERMAN ACT

27 While this right of the patentee to maintain the prices of his patented article, and Dick's control over the ink, may appear a violation of the Sherman act, in reality they are not. The Supreme Court has expressly decided that the control of the patentee over his patented article is not a violation of the Sherman act. The reasons will be apparent upon considering the purposes of the two acts. The patent act was for the purpose of inducing inventors to make inventions and to put the public in possession of a working knowledge of them, and the sole inducement was a monopoly granted to the patentee for a limited time to make money out of the invention, if he could.

28 On the other hand, the Sherman act was for the preservation of the rights of the public in trade which it already possessed and to prevent raising by a monopoly the prices of articles in which the public already had a right to trade.

29 The patent statute was for the purpose of bringing into existence trade in articles which never had and perhaps never would have existed but for the monopoly offered by the public as a reward to the inventor for inventing them, while the Sherman act was to preserve to the public free competition in trade which already existed and belonged to the public. The patentee takes no rights from the public when he restricts the conditions of use or price of sale of patented inventions. He is but dealing with his own. He can suppress it if he wishes. The public can have it without price simply by waiting until the patent has expired, but the patentee has a contract (his patent) giving him the exclusive right until that time. The public never had any right to sell ink for use with Dick's machine, for the machine never existed until he invented it. Therefore he has taken nothing away from the public which belongs to it, and there is nothing for the Sherman act to operate upon.

30 The control of the patentee over the conditions of use or sale of his patented article is not so absolute as it might seem. The only way in which he can get return from his patented article is by inducing the public to use it. If, then, he imposes restrictions which are too burdensome or which take away the

advantage of the public in using the article, he cuts down the sales which he might otherwise make. This fact alone puts a limit on the restrictions which the patentee will impose on his patented article.

THE BATH TUB DECISION

31 The patent involved in the bath tub decision was one relating to an implement for shaking sand, more or less automatically, on a red hot iron bath tub for the purpose of forming an enamel on the bath tub. Under the guise of licensing manufacturers under the patent to use the implement, a *combination of manufacturers* was effected, which prescribed prices and conditions under which bath tubs were to be sold. The *association* forbade the selling of " seconds " or bath tubs which were in any manner imperfect, and not only fixed the prices, but imposed penalties for selling below those prices. The *association* also provided a jobber's license agreement which he had to execute before he could purchase the licensed sanitary enamelware. Various zones were established which were to be preserved to specified parties. There were other regulations too numerous to mention.

32 The Supreme Court in the Bath Tub case held, in effect, that the manufacturers had formed a combination in restraint of trade and in violation of the Sherman act, and that the patent was a mere cloak. The vital objection was that the manufacturers formed a combination *between themselves*. The court did not decide that the patentee could not have lawfully imposed the same conditions separately upon each manufacturer as a license if there was no combination and conspiracy between the manufacturers. If the manufacturers had all had their relations directly with the patentee and there had been no combination between themselves, so far as the Supreme Court decided, it would not have been objectionable. The court did not decide whether or not it was lawful to regulate the price of unpatented bath tubs under a patent for a patented implement used in the manufacture of the bath tubs.

THE PROPOSED PATENT LAW REVISION

33 Following the Dick decision a flood of bills was introduced into Congress seeking to amend the patent statute to cut down the inventor's monopoly and greatly restrict his control over the property which he had created. The theory of the framers of these bills was that this property was going to come into exist-

ence anyhow, no matter how little the inducement, and it was perfectly safe to regulate it to any extent, any monopoly which remained in the inventor being mistakenly thought to be a free gift from the public instead of an inducement, without which the invention could not come into existence.

34 The principal bill, which was recommended by a majority (only) of the Patent Committee of the House of Representatives, contains almost every negative amendment of the patent law that anybody has suggested. This bill has not yet passed either house of Congress. The three principal provisions of the bill are:

a Compulsory licenses which are to be obtainable from a Federal District Court by anyone who can establish that the owner of the patent (not being the original inventor) has purchased the patent for the purpose of suppression. The Patent Committee of the House of Representatives was unable to point out any tangible instance of such patent suppression, and only an average of one to six out of about sixty witnesses who testified before the Committee, or who presented communications on the subject, was in favor of any such provision. A complete discussion of the provision would be beyond the scope of this paper, but a few of the main objections may be stated as follows:

If this amendment were made, no manufacturer would dare to patent or disclose anything but the preferred form of the invention, because inferior forms which he might patent and disclose could be manufactured by others, under the compulsory license, in competition with his preferred form. This might destroy the effect of a generic or parent patent which was parent to the children. It is unlikely that a court would require the licensee to pay a price commensurate with the expense to the manufacturer of the cost of developing the preferred form, so that the manufacturer would be at a disadvantage. The manufacturer could not afford to improve his product, because the moment he began to manufacture the improved form, somebody would demand the right to manufacture the poorer, original form. No manufacturer could afford to own more than one patent in a given line. The constant danger of litigation to compel a license would make patents much less desirable property than they are today, and greatly decrease their value. Thus the effect of the compulsory license would be to discourage invention instead of to encourage it. It is believed that there are very few instances of suppressing the best invention in a particular line, and so long as a manufacturer furnishes the public with the best form of the invention, it is to the benefit of the public to give him a monopoly during the years which it will take to establish the article thoroughly in the trade.

b The bill also forbids license restrictions as to the manufacture, use or sale of his patented product by taking away practically all power to enforce any such restrictions, even though the purchaser agreed to them in order to induce the purchase. This again would very greatly lessen the value of patents and consequently reduce the incentive to make inventions, so that inventions would not be made to the same extent as today. The bill forbids the patentee the control over his property which largely resides in the owner of unpatented property. It puts the inventor at a disadvantage as compared with the owners of other property.

c The bill also provides that a presumption that the Sherman anti-trust act has been violated shall be conclusively presumed, when any one of a large number of the most common business transactions is entered into in connection with patented property, regardless of any surrounding circumstances. If the patentee attempts to restrict the price at which the article may be resold; if he attempts to compel a purchaser to buy an unpatented article from him with the patented article (such as in the Dick case); if he purchases other patents with a view to preventing competition with his patented article; if he attempts to control the territory in which his article shall be sold; or to sell to one person on conditions less favorable than to another; or to do business under any other name than his own, or that of his firm or corporation, he is conclusively presumed to have violated the Sherman anti-trust act, and anyone who has been injured may bring a suit within three years after he has been damaged and recover threefold damages, the costs of the suit, and his attorney's fees. Moreover, the patent may be declared forfeited and the owner of the patent may be fined $5000 and imprisoned for a year. In other words, the patentee is tremendously worse off with his valuable property, which he has created with his own brain, and which is a great benefit to the public, than the owner of any other kind of property.

35 *There is grave danger in putting the knife to the inventor's reward.* The temptation may be strong to prohibit the patentee from exercising such control over the sale or use of his patented article as the Dick decision gives. It looks so easy simply to amend the patent statute and cut down the extent of the monopoly granted by the patent. It seems as though the public might just as well have this advantage as not. But, as a practical matter, it is to be considered whether the public would not lose more than it would gain. Taken as a whole, the price is a mere bagatelle which the public has paid for the inventions that have been produced solely as a result of the patent statute. The patents have not cost the public a single penny, for the inventors have, by their fees, paid all the cost to the Government of granting them. On the other hand, the price paid by inventors in the cost of experiments, and in the time involved and the energy expended, has been beyond all calculation.

36 I know of one machine in the shoemaking art upon which over $500,000 was expended before it was considered perfect enough to put on the market. Instances are not at all rare where $100,000 or more has been expended in developing an invention. Most of the large progressive manufacturing concerns of the United States maintain a corps of inventors who are seeking to improve their products and cheapen the cost of manufacture, all of which goes into the general fund of human knowledge, and, after the short period of the patent has passed, is forever at the service of anyone who wishes to use it. Not only have the patented inventions cost the public absolutely nothing, but the inventor will get no return whatever, unless he can succeed

in making money out of the invention. This means that he must *further* serve the public by supplying it with the patented product in order that he may have any return.

37 *The patent statute has been a cardinal factor in the development of our country.* No one statute in all history has made for the material advancement of mankind to an extent at all comparable with the patent statute. Man's hands have been multiplied and made more efficient and skilful by the inventions produced as a result of the patent statute, so that the average man today lives with a degree of comfort, a power of communication and transportation, a quantity of reading matter, a variety of pleasures and a control over nature which were unobtainable by the man of 100 years ago, regardless of his wealth.

38 Let us take the tools and appliances which the inventor has supplied the farmer as a typical instance. In 1791, the best plow was a wooden structure shod with iron, and it was so imperfect that but an acre of land could be plowed in a day, and even then the soil was not much more than scratched. The plow had hardly been improved at all in 40 centuries. Now, a steel plow turns up the ground so much deeper and better that a much larger crop is grown, and several times as much work can be done in a day with the ordinary one-horse plow as with the old form, while with the steam-driven gang plow 30 times as much work can be done in a day. In George Washington's day thrashing was done by the use of a flail, producing about five bushels of wheat a day. Now, a steam thresher can thresh a thousand bushels in the same time, and there are even steam-propelled harvesting machines which cut a swath 26 ft. wide through a field of wheat, and thresh, clean and sack the grain at the rate of three bushels a minute, and yet but seven men are required to run such a machine. All these changes have come about as the result of the American patent law, and practically within the space of less than a century. If there were time to review the similar changes in other fields of industry due to our patent law, it would read like a fairy tale. Many arts and industries owe their very creation and existence to the patent law.

39 *The inventor's reward should not be disturbed, but, instead, the patent law should be simplified and strengthened.* With the bargain already so tremendously one-sided in favor of the public, and with the burden already so heavy on the inventor, we should

be exceedingly slow to lessen the inducement to the inventor to continue his work. At the very longest, his monopoly can exist but 17 years. A considerable part of this period is usually taken up in getting the invention successfully upon the market, even in the case of the most successful inventions. The necessity he is under to sell his product is a natural limitation on the conditions which he may impose. At the most, the public need only wait the 17 years in order to have perfect freedom to make, use and sell the invention.

40 It would be unwise, in the extreme, to jeopardize the effective continuance of this most advantageous work on the part of the inventor by cutting down in any way the return to him which, in any case, costs the public nothing, and is a trifle compared with the benefit to mankind. The effect of any present change in the patent laws would not become evident for a considerable length of time, and it might take many years to recover the lost ground, not only in the degree to which we have fallen behind invention abroad, but in the loss of inventive power due to incentive to develop it.

41 The patent law needs changes, but changes to build it up, not to tear it down. The Patent Office should have a sufficient force of adequately paid examiners so that it can make practically certain it is issuing patents only for inventions which are new. The procedure of adjudicating a patent should be made cheaper, simpler and shorter. For that purpose there should be enough judges so that patent cases may be quickly tried by testimony taken orally in the presence of the judge, instead of by printed records of testimony taken slowly and expensively before a master and then read before a judge. The fees now payable to the clerks of the courts should be reduced to only a fair compensation for the services performed. And a single court of patent appeals should be established, instead of the present intolerable system of nine separate circuit courts of appeals, each having equal and independent jurisdiction in their own circuits of every patent.

THE V-NOTCH WEIR METHOD OF MEASUREMENT

BY D. ROBERT YARNALL, PUBLISHED IN THE JOURNAL FOR OCTOBER 1912

ABSTRACT OF PAPER

This paper explains the V-notch weir method of measurement and a convenient form of apparatus, the Lea recorder, which can be used for recording graphically and continuously and with a high degree of accuracy rates of flow over V-notches and other weirs. It is shown why the V-notch is the most accurate and convenient form of weir for general testing purposes.

The paper also gives details of tests made with the apparatus measuring hot boiler feedwater at the Dartmouth College power plant during both winter and summer load conditions. The results of these tests show the great accuracy of the V-notch at low rates of flow as well as high.

Results of additional tests recently made in Philadelphia and near New York are given which together with the Dartmouth College tests show that the V-notch method of measurement gives results at high, intermediate and low rates of flow which can be relied upon to within one per cent.

DISCUSSION

W. S. GIELE told of tests made under his supervision by the Harrison Boiler Works on a Cochrane independent meter which was equipped with a Lea recorder; these tests were made because at that time there were in this country no data available in connection with meters of large capacity. As to the correction for temperature of the water during the progress of the test, the speaker stated that no such correction is made because the V-notch is a volume machine, and the transformation from volume to weight is made in the cam shown in Fig. 3. But there is a temperature correction necessary between the temperature for which the cam is cut, and the temperature at which the measuring tanks were calibrated (in this case 3.5 per cent). It is a peculiar fact that this kind of instrument is to a large extent self-compensating as the submergence of the

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Presented at the Annual Meeting, December 1912, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th Street, New York. All discussion is subject to revision.

float varies with the density of the water, and thus in a measure compensates for the variation in the volume of the water going through the notch. In some tests made by the speaker the error was as little as ½ of 1 per cent.

The V-notch weir referred to by Mr. Yarnall is not in itself new, its formula having been investigated and developed by Thompson in 1858 and also investigated with more refined apparatus by Barr in 1907. The more general adoption of the V-notch weir has been handicapped by the lack of a recording apparatus sufficiently delicate to take advantage of the superior accuracy of the V-notch weir, particularly at low rates of flow and Mr. Yarnall's paper describes a recording apparatus which is intended to meet this need.

J. H. Browne described how the hook gage was applied to obviate the large expense and time necessary to test the type of meter used in the Dartmouth College tests. In Table 2 can be seen a hand-hole on the front side of the V-notch. In conjunction with the engineer at the plant the speaker inserted a hook gage in this hand-hole sufficiently far back from the V-notch so that it would not be disturbed by the flow of water, and took observations on the hook gage every three minutes for one hour and thirty minutes. Simultaneously the engineer took observations on the vertical scale in the case of the recorder. These observations were found to coincide with each other to the third decimal, in inches, that is to 0.001 in. By this and similar methods it was also proved that the meter is correct over a very fluctuating flow.

Fred. N. Connet thought that a wrong inference would result from the statement in Par. 13, that the accuracy of a venturi meter or pitot tube depends upon *velocity changes* and that fluctuations in velocity therefore impair the accuracy. While it is true that the differential pressure at the two points in a venturi tube is due to the difference in velocity at those two points, it is not true that it is due to any changing or varying in that velocity. Any inaccuracy due to a changing or fluctuating velocity is just as sure to apply to a V-notch as it is to a venturi or pitot tube. In the device described by Mr. Yarnall, the large tank exerts a steadying effect upon the velocity of the water and credit should not be given to the notch but to the tank. A tank used in series with a venturi tube gives exactly the same beneficial results, although such a tank is seldom required.

When installing a boiler feed meter of any type whatever it is customary to select one having a maximum capacity about twice the ordinary load. It is desirable therefore to have the greatest accuracy of the meter apply to rates which are approximately one-half the maximum capacity. The V-notch is more accurate for low velocities because there is a considerable movement of the float corresponding to fluctuations in the flow at that point. As the water, however, rises in the V-notch, the width of the weir becomes greater and the float movement corresponding to variations in velocity becomes less and less. As the paper states, a 90 deg. V-notch weir with a capacity of 100,000 lb. per hr. has a maximum float movement of 6 in., and at a 50,000 lb. rate the float movement is about 4½ in. At this rate a variation of 1/16 in. in the float elevation changes the meter readings about 2000 lb. per hr., equal to about 4 per cent of the nominal capacity. The error due to a departure of the float from its intended position will be relatively smaller in meters of greater capacity, and vice versa, but the capacity mentioned probably represents an average of the boiler feed meters in use in this country. In the venturi meter the total float movement is about 22 in. for meters of all capacities, and when running at half speed a variation of 1/16 in., which is more than would probably occur, corresponds to only 3/10 of one per cent of the nominal capacity.

The Author said that he had been working for some time on a compensating float of a varying section such that, should the density of the water change owing to changes in the temperature, it would correct exactly by weight for those changes due to its being immersed more or less. When a V-notch meter is used for measuring hot water, as the temperature rises the buoyancy decreases, and the float which is the actuating means for the recorder drops a little in the water. Over a range of about 50 deg. it compensates very closely indeed. The float used is a double conical float, with a 3-in. straight barrel. It was found that with the float so formed an almost complete compensation for the changes of temperature could be obtained. The tests in this direction are not finished yet.

The test referred to by Mr. Giele was made on a Lea V-notch recorder having a maximum capacity of 300,000 lb. per hr. It is interesting to note by referring to the data of this test in the paper that the compensation for changes in temperature was almost exact. The only correction necessary was for the temperature at which the test was run, namely 73 deg., while the cam of the Lea recorder was cut to measure water at 212 deg. This correction was predetermined from the known formula of the flow, which formula was used in plotting the cam for the drum.

INCREASE OF BORE OF HIGH-SPEED WHEELS BY CENTRIFUGAL STRESSES

WITH FORMULAE FOR FORCE AND SHRINK FITS

BY SANFORD A. MOSS, PUBLISHED IN THE JOURNAL FOR SEPTEMBER 1912

ABSTRACT OF PAPER

Unless proper precautions are taken, a high-speed turbine wheel expands at the hub a sufficient amount to cause an appreciable increase in the bore so as to make the wheel slightly loose upon the shaft, soon causing distress.

There is given in the paper a general discussion of stresses in a rotating wheel; a mathematical method for computation of the increase in bore of a rotating wheel due to centrifugal stresses; an investigation of the actual numerical value of the increase of bore under various practical conditions; an experiment giving an actual measurement of the increase in bore of a wheel at high speeds, showing close agreement with computed values; a description of methods of preventing damage due to the increase of bore by using large amounts of force fit; and a mathematical treatment of force fits.

The increase of circumference of the bore is proportional to the original circumference and the tangential stress and inversely as the modulus of elasticity. In the experiments the readings showed that the bore expanded at each speed an amount almost exactly equal to the computed values.

For a wheel with 12 in. bore and 30,000 lb. maximum stress, which is permissible with special grades of steel, this increase of bore comes out over 0.01 in., which gives an appreciable loosening of the shaft fit.

A complete treatment of the subject of force and shrink fits based on the maximum shear law is given for the first time so far as known.

When the hub is in place on the shaft, it is expanded by a certain amount and the shaft is also compressed by a considerable amount. The ratio of expansion of the hub to the total force fit is the same for a given wheel and shaft regardless of the amount of the force fit. A curve is given showing values for various cases. Curves are also given showing values of radial stress at the bore of the hub which is also the pressure between hub and shaft, and the maximum effective stress at the bore of the hub which is usually the greatest stress in the

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Presented at the Annual Meeting, December 1912, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th Street, New York. All discussion is subject to revision.

system. The usual case of a shaft with a comparatively small hole is practically equivalent to a solid shaft for these matters.

For an average case the hub bore expands about 0.6 of the amount of the force fit and for a force fit of one mill per inch of bore the radial stress is about 13,000 lb. per sq. in. and the effective tangential stress is about 27,000 lb. per sq. in. For other amounts of force fit the stresses are in proportion.

For the average case above mentioned the pressure to force the hub on the shaft is about 1560 lb. per in. of bore and per inch of hub length for a force fit of one mill per inch of bore.

DISCUSSION

Richard H. Rice said that the paper showed, first, that the computations made for stresses in wheels running at high speed are correct. The forms of wheels used in turbines and in air compressors and other high-speed machinery are complex, and the analyses for the solution of the stresses and strains in such wheels are also complex. It is gratifying to find that actual measurements on the many wheels measured confirm accurately our computations and show that the formulae are adequate for the purpose.

The paper also shows that wheels running at high speeds do expand in the bore, although some little question has been raised as to this, and the amount of expansion can be accurately computed. It also shows that such expansion can be adequately taken care of and that it is a matter of no importance whatsoever, so long as the designer knows the amount of expansion so that he can provide a forced fit somewhat greater than the expansion.

Wm. H. Kenerson said that it would help in an interpretation of the results of the tests described in the paper to know something of the length and character of the end of the little piston pieces running from the sleeve in the shaft to the hole whose diameter is being measured, and that he hoped the author would tell something about this, so that an idea might be gained of how much that distance changes when the shaft is going at high speed.

Mr. Rice replied to Mr. Kenerson's question that that point is provided for in the preliminary calibrations where the readings were calibrated by working on sleeves of known diameter. In reply to a further question he added that the sleeves provided were of such small diameter their expansion was negligible.

Wm. Kent asked how Poisson's ratio had been determined, and said that while he had seen many figures published of Poisson's ratio, he had never seen a statement of how it was measured. He desired to know whether there were any American experiments on the subject to determine Poisson's ratio.

Elmer A. Sperry wrote that he was personally interested in the paper, as he had himself pursued similar investigations especially upon the subjects treated in the first part of the paper, and apparently had carried them even further than the author. As a basis of two large gyroscopes which together constitute by far the most powerful gyroscope plant ever undertaken, he had two 50-in. wheels weighing on the order of 5000 lb. each, upon which rupturing tests, so called, were run. The real object of the tests was (*a*) to determine the integrity of the specific strength of the wheels; (*b*) to check them up with the elastic limit as indicated by a number of test bars taken from wheels; and (*c*), the most important, to make the interior portion of these wheels flow in such a way that in their natural state the whole interior of the wheel would be under pressure before finished boring. The speed was calculated at which the central part of the bore of the wheels, the general shape of the hubs of which were similar to Fig. 2 of the paper, would take a permanent set to the extent of several thousandths of an inch. The wheels were then put to this speed and the bore searched carefully for evidences of the permanent set. In each case it was found that this not only existed but was practically in accord with the quantities calculated. This was also an assurance that the wheels were solid and reliable in this critical zone or central region. Experience with these wheels would corroborate the statements made in the paper, which the writer looks upon as an extremely valuable and reliable contribution to the knowledge on the subject.

The Author. As Mr. Rice has already stated, Mr. Kenerson's point in regard to the validity of the measurements at high speeds was covered by the calibrating sleeve tests discussed in Par. 22. As stated, this sleeve had two different bore diameters, each being accurately known. The sleeve was a thin ring so that its increase of bore at full speed was very small and could be accurately computed. The amount was 0.0012 in. The increase of the bore

TABLE 2 VALUES OF POISSON'S RATIO (RATIO OF CROSS CONTRACTION TO DIRECT EXTENSION PRODUCED BY A SIMPLE TENSION)

Experimenter	Reference	Material	Young's Modulus	Poisson's Ratio	Method	Measurement
Wertheim	Annales de Chimie et de Physique. ser. 3, vol. 23, 1848.	brass		0.333	Tube closed at both ends subjected to longitudinal tension	Increase in volume of interior of tube and longitudinal extension
Wertheim	Annales de Chimie et de Physique, ser. 3, vol. 23, 1848.	glass				
Kirchoff	Poggendorff's Annalen, vol. 108, 1859.	steel		0.294	Wire subjected to combined twisting and bending	Twist and transverse deflection
Bauschinger	Der Civilingenieur, 1879	steel		0.284	Bar subjected to tension	Direct measurements of cross contraction and longitudinal extension
Bauschinger	Der Civilingenieur, 1879	steel (bessemer car axle)		0.261		
Bauschinger	Der Civilingenieur, 1879	tin		0.275		
Bauschinger	Der Civilingenieur, 1879	sandstone		0.075 to 0.250		
Amagat	Journal de Physique, 1889	steel	29.60 x 10^6	0.269	*a* Tube closed at both ends subjected to longitudinal tension	*a* Increase in volume of interior of tube and longitudinal extension
Amagat	Journal de Physique, 1889	brass	15.73 x 10^6	0.327		
Amagat	Journal de Physique, 1889	copper	17.82 x 10^6	0.327	*b* Tube closed at both ends subjected to (1) longitudinal tension and (2) to external pressure over its surface	*b* (1) Increase in volume of interior of tube (2) decrease of volume of interior of tube
Amagat	Journal de Physique, 1889	lead	2.28 x 10^6	0.428		
Mallock	Proceedings Royal Society, vol. 29, 1879	steel		0.253	Rectangular beam bent by couples	Longitudinal and transverse radii of curvature of surface

Mallock	Proceedings Royal Society, vol. 29, 1879	brass		0.325		
Mallock	Proceedings Royal Society, vol. 29, 1879	copper		0.348		
Morrow	Philosophical Magazine, ser. 6, vol. 6, 1903	steel (mild)	30.64×10^6	0.275	Bars subjected to tension	Direct measurement of cross contractions and longitudinal extension
Morrow	Philosophical Magazine, ser. 6, vol. 6, 1903	steel (Sheffield spindle)	29.05×10^6	0.276		
Morrow	Philosophical Magazine, ser. 6, vol. 6, 1903	brass (drawn)	13.70×10^6	0.341		
Morrow	Philosophical Magazine, ser. 6, vol. 6, 1903	copper (drawn)	17.73×10^6	0.327		
Schellens	Thesis M. I. T. 1911	steel (mild structural)	29.97×10^6	0.282	Bars jacketed with mercury	Increase in volume of mercury jacket and longitudinal extension
Schellens	Thesis M. I. T. 1911	steel (high carbon tool)	29.43×10^6	0.292		
Howard	Tests of Metals, Watertown Arsenal	steel				

shown by the instrument agreed exactly with this, showing that there was no compression of the pistons by centrifugal force, indentations of the wheel bore by the piston ends or other unlooked for effects at high speeds. The decrease in length of the pistons due to centrifugal force was computed and found to be absolutely insignificant. The ends of the pistons were rounded and carefully hardened.

In regard to Poisson's ratio there is but one published set of American experiments so far as I know; the matter has been completely settled by many European experiments, however. Through the kindness of Mr. C. A. Schellens I am able to append Table 2 giving the principal references in this matter.

EFFICIENT PRODUCTION OF CYLINDRICAL WORK

By C. H. Norton, Published in The Journal for January

ABSTRACT OF PAPER

Early grinding machines were designed for the purpose of producing a higher degree of refinement than was possible with the lathe, both being used as tools of refinement. Later developments show that the highest efficiency is secured in the great majority of cases by using the lathe solely as a roughing tool, transferring the entire responsibility for refinement to the grinding machine.

The process of roughing is not to be considered in the usual sense of turning to a few thousandths of an inch over the finished size, since this involves an element of refinement and loss of time. The workman at the lathe should use the coarsest feeds possible without regard to finish, calipering the work at the beginning of a cut only, where the tool should be fed by hand for a short distance for this purpose. While a piece roughed out in this manner may require a longer time for grinding than if roughed out more carefully with a certain degree of refinement, the combined time for lathe and grinding machine will be less than if part of the refinement was done by the lathe.

Several examples are quoted by the author of work which has been ground in accordance with the principles outlined. It is held that lathe departments and grinding departments should be conducted under one head, instead of separately as is usually the case, to avoid the tendency of the lathe department to consider its work as a finished product, and of the grinding department to insist on careful turning in order to make a better showing of time required for grinding.

DISCUSSION

R. H. Rice said that in his opinion one of the most important suggestions made in the paper is that the lathe and grinding departments should be one and the same. As soon as this idea is well inculcated in our machine shops, the full benefit of the point which Mr. Norton has suggested will be secured.

Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

G. I. ALDEN suggested that in the author's paper is outlined a field for the efficiency engineer which is in many respects perhaps the richest field that could be found, unsurpassed in opportunity.

WILLIAM KENT stated that efficiency engineers are asking for tabulated data on matters of this kind. They would like, for example, to know the time required for turning and grinding a cylinder of a given size and under given conditions. Such information is too valuable to be hidden in the text of papers and he suggested that where possible an appendix be added to such papers, giving information in tabular form, so that they could be compared with data of the same kind appearing in other papers.

H. P. FAIRFIELD. Mr. Norton's paper is of peculiar interest to me because of a series of tests recently made under my direct supervision in the interests of the Worcester Polytechnic Institute.

The tests were made in a Worcester shop and the aim was to determine in what manner and to what extent the lathe could best be used as a "preparing" machine for cylindrical work finished in the grinding machine. Mr. Norton's remark made in my presence, that a piece of cylindrical work properly prepared for effective grinding should "look like a storm at sea" led to making the tests. The work selected was a lot of forgings to be finished as spindles for heavy machine tools, also a lot of comparatively long and slender shaftings. The lathe and the grinding machine were in these tests considered as a producing unit and worked as such. The first cost of each machine was noted, the power necessary to drive each machine measured and rated, the price paid the operator was charged to each machine and tabulated in the results as was the cost and wear of the cutting tools. The work had the usual amount of excess metal to be removed and the problem assumed the form of a direct question, what is the method of least final cost for removing the excess of stock and what part shall each machine assume in doing the work.

In the case of the forgings the results showed that a certain excess of stock could be removed in the engine lathe with a lesser final cost, using the lathe purely as a roughing out machine, taking coarse feeds and whatever cutting speeds the cutting tools would stand without excessively rapid dulling of the cutting edges. In the case of the longer and more slender shafts it was in some cases found that they could be roughed out and finished at a lesser final cost in the grinding machine without previous lathe operations.

The conclusions drawn were that the cylindrical work in most shops could be well classified into a limited number of groups of machine parts arranged according to their weight, form and material. Also, that the lathes and grinding machines should be arranged as a production unit and treated in all cases as such. Further that each class of parts should receive an accurate time and cost study with the results carefully tabulated and analyzed; that time and cost studies should be frequently made to determine whether or not the classification of parts as arranged was the better one and whether the machines and tools used were the best obtainable for the object sought.

The Author. The facts brought out in this paper are the result of 12 years of patient work and experimenting. The majority of metal machine makers still labor under the impression that grinding is an additional operation in the creation of cylindrical work, and that they have simply to turn work as they have always done, allowing something for the grinding machine to grind off. That was not the idea that created the modern cylindrical grinding machine, although it was the idea that created the original cylindrical grinding machine. The modern grinding machine was originated to assist the lathe in creating cylindrical work and to make the process less expensive than it had been before any grinding was done—not simply to replace filing.

The suggestion of Mr. Kent is a good one. In Par. 35 are given all the details in connection with grinding certain shafts, though not in tabular form. These are what might be called countershafts. The cost of the wheels is given, the wear of the wheels, the cost of power, time and amount of steel removed with every cubic inch of wheel, etc.

THE POWER PLANTS OF TEXTILE MILLS

By John A. Stevens, Published in The Journal for December 1912

ABSTRACT OF PAPER

This paper describes the purposes which should be served by power plants in textile mills.

It calls attention to the individuality of each plant and to the special design and adaptation necessary if it is best to serve its purpose, showing how manufacturing conditions as regards use of low-pressure steam in textile mills make well designed plants for such mills differ from those which would ordinarily be best and most economical for other lines of industry.

The degree to which power plants in textile mills are complicated by use of water power requiring relaying by steam units is discussed, and the effectiveness of electric transmission for securing necessary flexibility under these conditions pointed out.

Several power stations recently installed under the writer's supervision are described and illustrated, the purpose being to call attention to particular features of each plant which illustrate points mentioned in the paper.

A more careful consideration of the advantages which might be secured by groups of mill owners combining to produce power in a single station jointly owned and operated by the group is urged.

DISCUSSION

Charles T. Plunkett inquired whether the author had found it desirable to heat a mill by steam from the receiver of a compound engine. While his plant was fitted up to use steam from the receiver, he had not found it economical to use steam from this source for any purpose except for power. It is not customary, however, in the textile mills, to use steam for heating during the day unless it is very cold. After the machinery is started the requirements to keep the mills warm are very light.

E. W. Thomas asked whether by condensing steam and using the hot water for heating the same economy would result. His

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attention was drawn to the possibilities of heating a plant by using the sprinkler pipes and having a valve to shut off the city supply or to turn it on in case of fire. By using hot water for heating the temperature could be regulated as desired.

Chas. T. Main said that in nearly every one of the woolen and worsted mills with which he had had anything to do in the last few years. the exhaust steam from the power plant had been used almost wholly in the manufacturing processes and that there had been practically no trouble where steam engines were used from oil in the water. By having the water delivered to tanks with an overflow at the top the oil could be skimmed off at the overflow and the water from the bottom used. Steam turbine plants were free from those difficulties because there was no oil in the exhaust steam.

A few years ago Mr. Main was employed as engineer for a large mill which was run entirely by water power, the only engines being small ones connected with the machine. Eighteen thousand tons of coal a year was being burned for manufacturing purposes and the company wanted more water power put in at a great expense. He advised them to save their money and put a part of that into a steam plant and use the exhaust steam for manufacturing purposes. The agent said: "If you say that to the directors you will get fired. You had better keep still."

Mr. Main called attention particularly to the fact that one of the most modern and up-to-date plants where a large amount of steam was used for manufacturing and a small amount for power, took just the reverse view from the writer of this paper as well as himself, and they were going to furnish all of the low-pressure steam direct from the boilers and run the power plant just as economically as they knew how for power only.

Charles B. Burleigh. The author has touched lightly on the subject of providing a combined steam plant of sufficient capacity to relay any water shortage and stated that it might be late to bring up this matter because many manufacturing plants utilizing water power have already been equipped with relay machinery.

As a matter of record I would like to state that previous to such equipment in the early days of the electric drive, earnest efforts were made by the representatives of the leading manufacturers of electrical machinery to bring this very feature to the attention of the hydraulic companies furnishing power to textile mills in New England but for several reasons were unable to interest them.

Many of the older textile mills were located with regard to their proximity to available water-power, thereby in most cases sacrificing many other important considerations, such as light, air, fuel and transportation of goods and numerous other items which have an important bearing upon the cost of the finished product.

The developments of modern genius have made these sacrifices unnecessary in the modern mill. It is today not only possible but would be desirable in large water supplied textile centers, notably Lowell, Lawrence and Manchester, to combine and provide a steam relay of sufficient capacity to supply any deficiency in water-power. This should be located on tide-water where fuel at minimum price and ample low cost water are available for the production of power at minimum cost. That these conditions warrant the most careful consideration of the power consumer is perhaps best evidenced by the fact that many of our large textile mills so located as not to be able to utilize water-power are finding it to their advantage to purchase their entire power from tide-water steam plants.

The Author. In reply to Mr. Plunkett, almost the same argument holds for receiver steam taken from an engine as for steam taken from the stage of a turbine. Where there are uses which can be served by steam at low pressure, exhaust or low pressure steam from power units should be used. The changing of molecules of water into steam represents a definite quantity of energy and it makes no difference what kind of steam is used. As long as it is steam, the heat is available for other work.

Two things that a manufacturing company can do to make it easier to stay on earth in a business way are to *avoid operating condensers where heat is required in the mill; and to avoid wasting steam to atmosphere at any time.*

If running entirely non-condensing without a controlling feature there would be a waste from the time when the use for low-pressure steam dropped off, as it usually does, say at half past four in the afternoon. But by the use of the steam turbine there can be, so to speak, 5000 lb. an hour extraction, or if the turbine is large enough, 60,000 lb. an hour, or such quantity as is required absolutely under control automatically. If, say, 16,000 lb. an hour are wanted for the heating coils and dyehouse when starting in the morning, that quantity can be supplied; and if later, as at half past eleven in the morning, the demand drops off, the supply will be cut down, and at half past four in the afternoon cut off absolutely. These machines will operate to that degree automatically and at a pre-determined pressure on exhaust mains.

In the low pressure stages of some turbines, the revolving parts operate in a vacuum, when all steam possible is being extracted and there is relatively little friction and little additional cost of power when not in use.

The use of controllable exhaust steam makes an absolute and ideal arrangement for operating a plant under best conditions. But let us bear in mind that in arranging a plant of this kind, it must be automatically controlled, the low pressure steam being supplied to meet any demand which may take place at any time.

I have found the range of steam supply from the receiver of an engine to be very limited and a condition as suggested by Mr. Plunkett might exist in some cases since such supply disrupts the balance, governing and operation of the engine, while with the steam turbine of the bleeder type the range may be anything from a very small amount to the entire amount of steam required to operate the turbine non-condensing. One of the best things to do in making arrangements for the power plant is to find out how much steam is to be used for heating the mill and the aggregate demand for low pressure steam in the plant, then the plant can be powered (engined or turbined) to make the total heat balances correct, and the question as to what is most desirable can be calculated to a nicety.

As to another point, it is very desirable that we should have more than one power furnishing unit, engine or turbine, in a manufacturing plant. That is why I have spoken in my paper of relay power, and this relay power might be purchased from the central station or part of the regular power from the central station, cheaper than it could be supplied by condensing units at the plant in question; that is (and starting all over again), the first thing to be determined in any plant is how much heating and manufacturing steam is required. This heating and manufacturing steam should then be supplied from non-condensing power units (including pumping and auxiliary equipment); the next step is to find whether there is any water-power available at the property or central service power; and the third step to find how this additional power can (over and above the by-product power) be most economically supplied.

In friendly criticism of the condition mentioned by Chas. T. Main of " one of the most modern and up-to-date plants where a large amount of steam was used for manufacturing and a small amount for power," I would state that, for whatever steam is going through their condensers, they are realizing a total thermal efficiency of around 20 per cent, wherein, if they were to reverse the process and make use of their exhaust steam, they might realize a total thermal efficiency of, say, 75 per cent, by running their plant non-condensing.

Mitigating their situation, I might say that sometimes the power plants have to be so located that the companies cannot avail themselves of the use of exhaust steam from power units or the auxiliaries of power units.

I wish further to go on record at this time as stating that the powering and heat balances are of the greatest importance to textile plants and should be taken up by men conversant with the whole subject, if best results are to be expected.

MEASUREMENT OF AIR IN FAN WORK

By Charles H. Treat, Published in The Journal for September 1912

ABSTRACT OF PAPER

The paper discusses the use of the pitot tube for fan testing with particular emphasis on the correct kind of tube to be used. It describes a simple and accurate method of calibration of impact and static orifices, and the instruments to be used in fan testing, as well as the general method and arrangement of the tests. It shows further the derivation of the formula for friction in test pipe, and the method of correcting test results to standard weight air. The paper further contains proofs that the volume discharged from a fan is the same at all densities, other conditions being the same, and indicates the formulae and calculations used in the test, such as the formula for the determination of air horsepower on the discharge and suction side, efficiency of a fan and its speed. Finally, the question of the average velocity of flow in a pipe is discussed.

CLOSURE[1]

The Author. Mr. Carrier brings out a point worthy of particular attention when he places the blame for some of the discordant results of tests on leakage. I would not limit to leakage on the static side only, but anywhere in the connections. It is important that these easily cared for precautions be taken in any testing work and no less so in pitot tube air measurement.

In trying for leaks, pressure is best applied at the pitot tube orifices so that all the piping will be just as it is to be for the test. This method is noted in Par. 24 together with a caution against stopping the connections and drawing over liquid into the rubber tubing. These points should be carefully looked into before every test and it has been the regular practice in work under the writer's charge.

In regard to the detail of arm carrying the pitot tube the only

[1] The discussion was published in the Journal for February.

Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

objection to one tube inside the other is the smallness of the inner or the largeness of the outer one. In the first case it is difficult to clean the inner tube of dust or of liquid if it comes over from the manometer. In the second case the size of arm is objectionable. A better way of making the arm is to extend it through the measuring pipe at both sides. What slight obstruction there is to smooth flow is then constant for all positions of the pitot tube across the pipe.

I cannot subscribe to Mr. Carrier's statements as to fan efficiencies.

I am grateful to Mr. Moss for putting into the discussion some of the results of his experience in this field.

In regard to setting inclined manometers at zero angle much the best way found is to fill the tubes nearly full of gasolene, leaving only good length air bubbles, corking up the open ends and using the tubes themselves as a level. If they are good this affords means for very accurate setting. After setting the gage the excess gasolene is run out leaving them about half full ready for use.

Our manometers had graduations for different positions to give 2, 5, 10, 20, some of them 40 slant readings to one vertical and the zero angle on the circumference of the front plate and the reference line on the back plate. With the back plate set with its reference line opposite the zero line on the front plate when the tubes show level, any slant may be had by swinging to it.

The graduations need to be fine and accurately placed and at a good radius from the pivot, which should be well made so that there is no lost motion. These precautions are essential for good readings at the small angles 20:1 and 40:1.

The specific gravity of gasolene when filled to a hook gage mark in the neck of the can is usually determined by the weighing method. As two manometers are almost always used, it is convenient to check the specific gravity from time to time using water in one manometer and gasolene in the other and applying the same pressure to one leg of each, the height of water being divided by the height of gasolene. A can of gasolene if kept fairly well stopped does not change much in specific gravity, nor does that left in the manometer change fast. This point of density of gasolene must be watched, however, and the second method affords a convenient way.

In connection with gasolene manometers there is some apprehension in regard to gasolene vapor in the connections affecting the readings. The apprehension is found to be groundless when it is tried out. Even when the manometer is set to the smaller angles the tube and connections can be swung from several feet above to as many below without any noticeable change in the manometer reading.

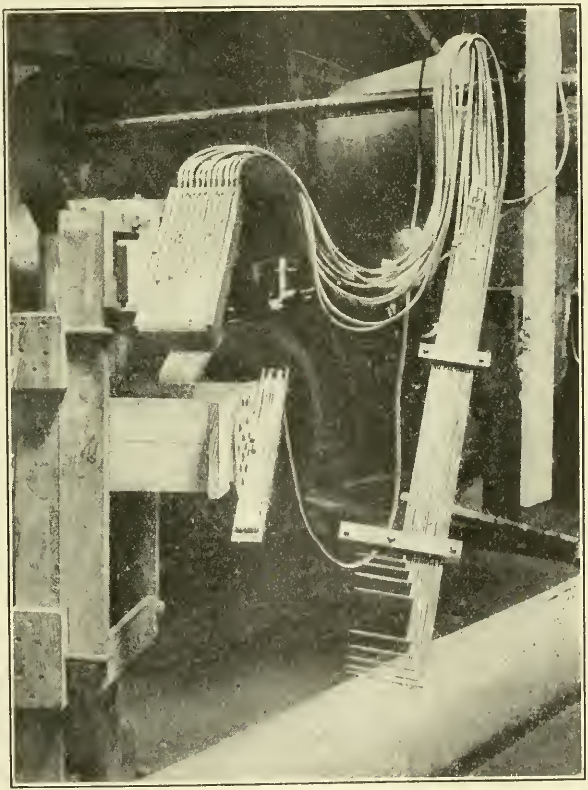

Fig. 14 Pitot Tubes ready for Measuring across Pipe with Inclining Gasolene Manometers

In the use of manometers in this pitot tube work, whether water or gasolene be used, any change in the volume in the connections from evaporation of the liquid is freely vented through the tube orifices or at the open leg of manometer when both legs are not connected, and therefore no error can result from vapor pressure.

Fig. 14 shows an inclining manometer as described. The upper instrument is an inclining averaging manometer by means of which the mean reading of ten pitot tubes can be obtained. It is connected to give average velocity pressure across the pipe. The left leg of the manometer is connected to a static of one of the pitot tubes. The arrangement of static is usually correct, but when the amount in the pipe is disturbed the static is not uniform and constant across the measuring pipe, and static and total or impact must be taken separately. The discharge from a fan with outlet open cannot usually be measured in this way.

In Figs. 15 and 16 the areas and sections of the several tubes are all made the same. If AA is the level of the liquid when all tubes are open and if the liquid is depressed in the right-hand tube amounts a, b and c as the areas are the same the displaced liquid must rise in the left tube an amount $a\ b\ c\ 0$.
Add 0 to a and we have A, $b + 0 = B$, $c + 0 = C$

$$a+0 \quad + \quad b+0 \quad + \quad c+0 \quad = \quad 4 \quad 0$$

or

$$A \quad + \quad B \quad + \quad C \quad = \quad 4 \quad 0$$

and the mean reading

$$\frac{A + B + C}{3} = \frac{4\,0}{3}$$

For any number of manometer tubes n we have for the mean reading

$$\frac{A + B + \text{etc.}}{n - 1} = \frac{n}{n-1}\,0$$

In use the distance 0 requires to be taken and multiplied by $\frac{n}{1n-}$.

So far as known this is a new form of manometer. It is interesting to watch the slight fluctuations in some cases of pressure across a measuring pipe. Plate glass was used over grooves milled in a brass body for this instrument.

The inclining manometer is accurate for small heads if the tubes are parallel and straight. The accuracy was tried out by simultaneous measurement of the pressure in connecting tubing by such a manometer at a 40 to 1 slant, by a hook gage on a good manometer and by a gasometer arrangement suspended inside a chemical balance. The measures checked very closely or to about 0.001 in. of water.

Mr. de Laval confers a favor by calling attention to the matter of determining the density of air under measurement giving a formula for density. The tables published by the Navy Bureau of Construction and Repair show the weight of air for different temperatures, barometer readings and humidity up to 100 deg. and are a time saver within their range. Formula [15] applies to any gas by using the density of the gas measured. (See also Pars. 44 and 45.)

As to measuring the velocity of air flow in a pipe with the pitot tube at the center, the correction for average velocity should usually be determined by trial and especially if the pipe is short or if flow is in any way irregular. If gates are used on the measuring pipe it is necessary or the error may be considerable.

As to the velocities of air affecting the correctness of the pitot tube readings my evidence is that these readings are correct at least to the limits stated and up to the speeds experimented with. That is, both static and impact orifices if they are as in Fig. 1 give true static and true impact pressures. The method of calibration is simple and direct especially for static orifice.

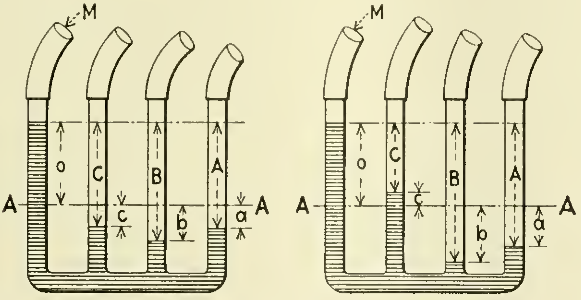

Fig. 15 Fig. 16

Equal Areas and Sections in Pitot Tubes for Use with Inclining Manometer

Possibly Mr. de Laval's experience has been with some of the forms having a faulty static orifice with which calibration was required to determine a constant in the relation $v = \sqrt{2gh}$. The form shown in Fig. 1 is simple and easy to make, the tip consisting of a $\frac{1}{8}$-in. tube inside a $\frac{1}{4}$-in. diameter tube with walls about $^1/_{32}$ in. thick. Both static and impact are correct if made as shown. Accurate pressure measuring instruments are available and must be used and the ordinary precautions taken against leaks, etc., as noted through the paper and in Pars. 18 to 25.

THE VAUCLAIN DRILL

By A. C. Vauclain and H. V. Wille, Published in The Journal for October 1912

ABSTRACT OF PAPER

In the usual type of drill there are four distinct cutting edges. The actual cutting, however, is done mainly by the two edges extending from the outer circumference to points near the center. At the central portion of the drill are the two shorter cutting edges constituting the "chisel point" which do not cut freely and introduce stresses tending to split the drill.

The paper describes a new type of twist drill which has two radial cutting edges and in which the usual chisel point of such drills is eliminated.

In this drill the stresses due to the chisel point are absent and the arrangement of the cutting edges is such that a greater thickness of metal is secured at the center of the drill, adapting it to heavy feeds by which means the most economical results are secured in drilling.

Tables are given showing the results of comparative tests with the Vauclain and regular types of drills, indicating a saving with the former of over half the horsepower expended with the latter type.

DISCUSSION

J. Sellers Bancroft asked if any efforts have been made to ascertain the accuracy of diameter of holes drilled with the Vauclain drill. He thought it would be difficult to get the point of the drill exactly central, and in the production of holes of accurate size it is necessary for the reamer, which follows the drill, to have a definite amount to take off throughout. This amount should be neither more nor less.

H. P. Fairfield. The report of the horsepower expended as given in Table 3 shows a remarkable difference between the regular and the Vauclain drills. It would seem as if such differ-

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

ences in results could not be due to the design of the drills themselves, but must be the result of the method of testing. It would be interesting, therefore, to know how these tests were made and the apparatus used to measure the efficiency of the several drills. The reader could then analyze the tests and judge for himself as to their reliability and exactness. In much of the ordinary drill testing, the weaknesses and friction losses of the drilling machines are registered and charged to the drills being tested, which is obviously unfair. Several years ago at the Worcester Polytechnic Institute a drill testing dynamometer was developed which obviates such errors, registering only what is taking place at the drill point and entirely eliminating the drilling machine from the readings taken. If anyone compares his dynamometer results with the power input of this machine he will be shown conclusively that tests based upon the differences in power input are extremely unreliable. It is for this reason that the writer believes the method of conducting the tests should have been included. In a series of dynamometer tests upon a regular and a Vauclain drill made since reading the paper, the results showed no material differences in horsepower expended, and the writer cannot see why there should be such differences as shown in Table 3. As furnished him, the Vauclain drill is essentially a point thinned drill. Therefore the pressure at the point is reduced and the distortion in the machine lessened. However, if the regular drill is point thinned as is often done, the results in thrust are essentially the same.

The Vauclain drill appears to lend itself more readily to the point thinning principle than does the regular drill, and if extended use and tests should prove this to be so, it is obvious that an advance in drill construction has been made.

E. C. Peck. This paper points out a great many weaknesses of the well-known twist drill and has attempted to prove the superiority of a new type, but the author has described neither the apparatus nor the exact conditions under which the tests were made, in a way such that the student may judge to what particular detail the difference in results is traceable.

In Par. 1 he says the best definition of economical drilling is rapid drilling; this is not necessarily true. The writer has drilled cast iron 4 in. thick with a 1½-in. drill at the rate of 64 in. per min., probably the record at this date for rapid drilling, but it was not economical because it consumed too much power and the drill was too near breaking all the time. A better definition of economical drilling is " the greatest amount of drilling that can be done per $1, counting the cost of time, power, machinery and drills."

In Par. 8 he says " The speed remaining constant—the power consumed by the *machine* remains constant for all feeds." It would be interesting to know how he determined this, as the coarser the feed the heavier the pressure on the drill to make it penetrate, and this puts more pressure per square inch on thrust bearings and feed parts which in turn increases friction.

Referring to Fig. 1, the cutting edges *A* and *B* being ahead of the center presents an advantage that the author has not mentioned, viz., they make a shearing cut with a tendency to carry the curling chips away from the axis of the drill.

The author lays stress on the splitting of drills and demonstrates the reason for this failure, but the splitting of drills is not a serious matter and a split drill usually shows a defect in the material or improper grinding, a fact which any large user of drills can easily verify by careful observation. The writer is in a position to observe the performance of several thousand drills each month which are tested to destruction under severe conditions and not one in 10,000 fail by splitting. If the chisel point spoken of has an inclination to the cutting edges *A* and *B* as shown in Fig. 1, there will be enough clearance at the center and the chisel point will cut easily enough to avoid splitting.

A great defect in the author's proposed drill, as shown by the writer's experience, is its inability to penetrate hard material. This is apparently due to the extremely thin center not being able to withstand the heavy feed pressure necessary to penetrate hard material. A more serious defect is the actual pressure of the chip against the surface *O* in Fig. 7. It does not curl freely as in the drill shown in Fig. 1 because there is no room; it must slide against the shoulder *O* Fig. 7.

In the regular type drill the cutting edge is extended past the axis an amount which allows free curl to the chips. If the regular and proposed drill used in the author's tests were properly thinned to the same thickness, there should be less power consumed by the regular drill because it bends the chips better.

Tests with Vauclain and regular drills made from the same bar of steel and heat treated alike showed in every case that to withstand heavy feeds (0.100 in.) the temper of the Vauclain drill had to be lowered 20 to 30 points below the regular drills to keep the centers from breaking and they were then too soft for high speeds.

The tables do not show the "rapid drilling" which might be expected from the author's statements. The highest rate given is 15 in. per min. and double this amount can be done with regular drills. It would therefore seem that more extensive tests will be needed to make the superiority of the Vauclain drill apparent.

The Author. In reply to Mr. Bancroft's question, accurate grinding of any drill is essential to the production of holes of accurate size. There is no difficulty in obtaining correct grinding in the Vauclain drill. No drill should be hand ground, and proper grinding machinery has been designed and built for grinding the Vauclain drill correctly. It is interesting, however, to note in this connection that much of the grinding of the Vauclain drills during the development was done by hand until the time when proper grinding machinery was available.

Replying to Mr. Fairfield, the author wishes to state that the remarkable difference in horsepower expended was not due to the method of testing but to the comparison between high speeds and heavy feeds. In other words, with a given rapidity of drilling a high-speed drill is made to depend upon high speeds and moderate feeds. The Vauclain drill utilizes heavy feeds and moderate speeds, the speed being kept just high enough to maintain within the drill a sufficiently high temperature to operate most successfully.

The author is not aware of any Vauclain drills having been furnished the Worcester Polytechnic Institute for the purpose of tests, and is of the opinion that perhaps such tests may have been made without a proper understanding of the intent of the drill design.

In reply to Mr. Peck, the apparatus and conditions under which the tests of the Vauclain drill were made were as follows:

The drilling machine used was a 60-in. radial drill press, one of a number built by Wm. Sellers & Co., Inc., of Philadelphia, and driven by a 20-h.p. variable speed direct-current motor. Current was supplied by an independent generator so that the machine was entirely segregated from shop lines, the object being to maintain as constant a voltage as possible. A Westinghouse recording wattmeter, also an ammeter and volt meter for direct readings were located about 75 ft. from the machine so that readings could be taken without encountering the dangers of flying parts of broken drills. In this same location there was installed a cut-out switch so that the machine could be stopped at any time without approaching it. A steel guard was placed about the drill spindle as a further protection against flying pieces of broken drills.

The material drilled was tough, hammered steel of approximately 0.45 carbon. Heavy slabs of this material were used so that holes would have to be drilled through a considerable depth in all cases.

The author in stating that the best definition of economical drilling is rapid drilling believes he is correct and that Mr. Peck has misunderstood the statement. The most costly element in drilling is that of time; and, by the saving of time, assuming a rational design of drill and of horsepower consumption, the amount of drilling that can be done per unit of cost will increase as the time consumed decreases.

In Par. 8, referring to the statement, "the speed remaining constant, the power consumed by the machine remains constant for all feeds," the author should perhaps have explained this matter more in detail. It is true, as Mr. Peck has stated, that the coarser the feed the heavier the pressure on the drill to make the cut, and this puts more pressure on the thrust bearings and feed parts, which in turn increases friction. Attention is called to the fact, however, that the friction due to end thrust of the drill is so small as compared with the total power consumed by the friction of the machine that it may be considered negligible so far as power consumption is concerned. That the power consumption varies directly as the speed is but a mechanical law which may be verified at any time and by anyone by electrical readings. To elaborate this further, assume that with a certain size drill and a given rate of feed and speed there is a gross consumption of 6 h.p., and that half of this power is consumed by the machine, leaving a net cutting horsepower consumed of 3. Next assume an approximate doubling of the rapidity of drilling. If this is obtained by doubling the speed, there will be a gross consumption of approximately 12 h.p. If, however, the rapidity of drilling is approximately doubled by increasing the feed and permitting the speed to remain unchanged, the gross consumption will be approximately somewhat less than 9 h.p. In a twist drill of the ordinary design, the difficulty of penetration and consequently the end thrust of the drill is aggravated by the chisel point. In the Vauclain drill, there being no chisel point, the end thrust upon the drill is very much less, consequently heavier feeds can be used in the Vauclain drill with less distress to the feed mechanism than would occur with the use of the ordinary type of twist drill.

The author cannot agree with Mr. Peck's statement that the splitting of drills is not a serious matter, and that the drill usually shows a defect in the drill material or improper grinding. The author has had a very large and intimate acquaintance with drills of all kinds. The central weakness of a milled drill is well known to all drill users. In the break-down tests made for the purpose of comparing the Vauclain drill with the ordinary design of drill, the ordinary designs of drill almost invariably split longitudinally, while the Vauclain drills, standing up under very much heavier duty as shown by the test data in the paper, fractured only when the torsional capacity of the section had been reached. Some of the drill manufacturers today, appreciating the seriousness of the central longitudinal weakness of the ordinary drill, have thickened their drills in the center, but this has increased the chisel point, consequently the difficulty of penetration. In the Vauclain drill there is no chisel point, consequently it may be made sufficiently thick in the center to enable the full torsional value of the drill section to be realized.

The author must disagree with Mr. Peck's statement in reference to the inability of the drill to penetrate hard metal. The Vauclain drill is especially adapted to the penetration of hard metal. It has no "extremely thin center." The so-called point on the Vauclain drill is merely the absence of a chisel point and is the strongest and most lasting and perfect part of the drill. It will not burn and it will not break under duties which would destroy the drill in every other respect.

With regard to the chip not curling, this is also incorrect. Since the cutting edges pass through the axis of motion, the chip at its inner edge has a length of zero while the maximum length of the chip is at the outer edge, consequently the outer edge of the chip is in rapid upward motion while the inner edge is approximately at rest. These circumstances, combined with the flute of the drill, give the chip the proper curl. No difficulty has been experienced with the Vauclain drill in this respect.

As to the temper of the drills having to be lower than that of the regular drills, this is not at all necessary, as stated by Mr. Peck, to prevent the centers from breaking. The author has stated that the Vauclain drill is a heavy-feed drill and has pointed out and substantiated the fact that high-speed drilling is less economical than heavy-feed drilling, also that high-speed drilling is the result not of desire or advisability, but rather of inability to obtain, in the ordinary type of drill, any great amount of physical strength. In the Vauclain drill a tough rather than a hard drill is required, and it is intended that these drills shall be drawn at a lower temperature than the high-speed drill of ordinary type.

With reference to the drilling of 15 in. per minute, it is to be understood that this was done in a piece of 0.45 carbon hammered steel, approximately 4 in. thick and that the drill was permitted to emerge from the bottom of the work under full feed without the slightest injury to the drill. In the author's opinion, the drilling of 64 in. per minute with 1½ in. drill in cast iron is not to be compared in severity with the test just referred to. The greatest evil of end thrust on an ordinary drill is that under heavy duty it is apt to break when emerging from the work. With the Vauclain drill feeds of ⅛ in. per revolution have been successfully carried with 1 9/64-in. drill at high speeds.

TESTS OF A 1000-H.P. 24-TUBES HIGH B. & W. BOILER

By B. N. Bump, Published in The Journal for October 1912

ABSTRACT OF PAPER

The tests described in this paper were made on an inclined header Babcock and Wilcox boiler, with superheater and mechanical stoker. The experimental unit was installed for the purpose of determining the maximum heat efficiency and fuel economy, and the variation of such efficiency with changes in the boiler rating, also to gather data useful in the design of a unit for a large installation. The peculiar feature of the boiler is the unusual height; the sections being 24 tubes high.

A Foster superheater was placed between the top row of tubes and the boiler drums, and the gases entered the superheater after passing over 24 tubes. The superheat was found to go up with the boiler rating, increasing from 30 deg. to about 75 deg. fahr. for a change in rating from 55 to 120 per cent.

The fuel was burned on a six retort Taylor stoker having a grate area, exclusive of dump grate, of 62.5 sq. ft. One of the results of increasing the height of a boiler is a large ratio of boiler heating surface to grate area, which in this case was 160 to 1. Such a large ratio limits the capacity of the boiler, making it impossible to run at high boiler ratings.

The best combined efficiency, 81.3 per cent, was obtained at about 56 per cent of rating. The efficiency decreases slowly with an increase in the boiler rating. The low rating tests show exit gas temperatures but little above the temperature of the saturated steam in the boiler. The radiation losses are low considering the exposed condition and the low atmospheric temperatures surrounding the unit.

DISCUSSION

W. D. Ennis. The results of these tests do not apparently harmonize with principles usually accepted. It is customary to think of a 3 or 3½ lb. rate of evaporation as that of maximum efficiency. At rates below this, the efficiency is reduced by the increased proportion of radiation loss, and by the lower furnace

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

efficiency, resulting from the low rate of combustion and necessarily excessive air supply. At evaporation rates higher than 3 or 3½ lb., efficiency is gradually reduced because of increased loss to the stack, as indicated by rising flue gas temperatures.

In this boiler, the efficiency steadily decreased as the rating increased, and the best efficiency was reached at an evaporation rate below 2 lb. When efficiencies are said to decrease at low rates the usual proportions of design are assumed: say with soft coal, a heating surface to grate surface ratio around 50. A 3 lb. evaporation rate means with this ratio, a rate of combustion of about 15 lb. per sq. ft. of grate per hour. No rate of combustion as low as this was reached in the present tests. In this boiler, with its unusual ratio of heating to grate surface, low rates of evaporation were not accompanied by low rates of combustion. At no time was the furnace efficiency notably lowered from the good average maintained.

It may seem that this scarcely explains the rate at which the efficiency apparently decreases with increased evaporation. As large a heating surface as was provided should have more completely absorbed the furnace heat. If Fig. 1-a is a scale drawing, a slightly better distribution of gas velocities would have been possible. It is quite easy, however, to over-emphasize the rate of decrease of efficiency, particularly as the *rating-combined efficiency* and *combined efficiency-gas temperature* curves of Fig. 2 are both represented to a distorted scale. The base line is that of 70 per cent efficiency, not of zero efficiency. The man on the street would say that the efficiency was about constant. In fact the curve of coal consumption against percentage of rating, Fig. 2, can scarcely be distinguished from a straight line. The flue gas temperature was 360 deg. at 56 per cent of rating and 400 deg. at 96 per cent: both figures are unusually good, with not much difference between them, certainly not more than would have been offset by the probably excessive air supply at the lower temperature and rating had the boiler had a grate of normal size. The difference between the efficiencies at half load and full load was about 1½ per cent. This means an excess coal consumption at full load of about 0.05 lb. per h.p-hr. Under the most unfavorable conditions, continuous service, the boiler running at full load would waste about $^1/_5$ ton of coal per year per horsepower capacity. To offset this waste it would be necessary to duplicate boiler, piping, smoke flue, etc., at an initial cost of perhaps $20 per h.p. The saving of $^1/_5$ ton of coal per year, which is the maximum possible, would usually not pay fixed charges on an investment of $20.

William Kent. Fig. 2 confirms what has been generally found, that there is a slight decrease in efficiency with increased rate of driving of the boiler, and that decrease will be less the more the theoretical ratio of air approaches the combustible. If air supply is excessive the efficiency will fall off much more rapidly than is shown in Fig. 2. The reason why the maximum efficiency is shown at such a low rate of driving is undoubtedly due to the fact that this boiler was thoroughly covered with non-conducting material and the loss by radiation was extremely slight.

Professor Ennis has spoken of the rate of combustion and the ratio of heating to grate surface. Probably 15 years ago, at a meeting of this Society, in discussing a paper by W. W. Christie, the writer showed that there was no change in efficiency necessarily due to a change in the rate of combustion, between 5 lb. and 240 lb. per sq. ft. of grate surface per hour, except the loss due to sparks and cinders blown into the stack at the higher rate of driving. There is no necessary relation either between the rate of combustion and the excess air supply over that theoretically required; that is, with a rate of combustion as low as 5 lb. per sq. ft. of grate surface per hour, perfect combustion is possible with a certain small excess air supply, and at 20 times this rate without any greater percentage of excess air. The two variables are the thickness of fire and the amount of draft, both of which are under control of the fireman, and excellent results are also attainable with a high rate of combustion, provided the grate surface is small enough, and the draft and thickness of fire regulated to get the proper analysis of the gases. If there is about 3 per cent of oxygen in the waste gases, and in the case of a coal-burning furnace, an even fire, there will not be more than one-half of 1 per cent of CO, and that condition will give the maximum boiler efficiency, provided the baffles are properly arranged and there are no leaks of air or other troubles, and the boiler is not being driven beyond its most economical rate.

J. H. Browne said that the method of baffling this boiler was somewhat new. He had seen trials with a similar method of baffling, but the experiments were not continued long enough to be conclusive. It seemed to him that although the method of developing a baffling material was interesting, the creeping of the tubes would break up the material, and he asked if the author had data on this.

The interesting fact was shown that the best economy was at from 50 to 60 per cent of the boiler rating, possibly accounted for by the superior installation of the boiler. In view of the fact that the ratio of 56 per cent appeared to be the best, this large boiler had at least one advantage from a commercial standpoint. Anyone who had to do with boiler-room operation no doubt knew that the average fireman liked to run about twice as many boilers as necessary. With a plant designed so that it would run at best efficiency at 56 per cent, this matter had been helped. On the other hand, a good deal more money was invested for the same size boiler under these conditions.

D. S. Jacobus. Mr. Kent has said that the percentage of oxygen in the flue gases might to advantage be made lower than is indicated by the tests. An important feature of the analyses is that they nearly all show some carbon monoxides. The determination of carbon monoxide in boiler tests is often subject to considerable error. In the present instance the analyses were undoubtedly correct, and the limitations in efficiency through striving to run with but little excess air, or a low percentage of oxygen in the flue gases, is clearly brought out.

On decreasing the amount of excess air there is a tendency to approach a zone where carbon monoxide will appear in the flue gases. The better the furnace the higher the percentage of carbon dioxide will be before the carbon monoxide appears. In endeavoring to obtain high efficiencies, we take great care to watch for carbon monoxide. It is often an easy matter to get, say, 10 or 11 per cent of carbon dioxide with little or no carbon monoxide, but after exceeding 13 per cent of carbon dioxide the furnace must be exceptionally good to consume all of the carbon monoxide.

Measuring the furnace temperatures has been suggested. It is extremely difficult, if not impossible, to do with accuracy, as the effect of the radiant heat complicates matters. A long time ago I calibrated a Uehling-Steinbart pyrometer, and great difficulty was experienced in obtaining comparative temperatures.

In an ordinary furnace the temperature of the gases may be different from the temperature due to the radiant heat and on this account there are variations depending on the form of the end of the pyrometer which is exposed to the conducted and the radiant heat. The arrangement of the water heating surface with respect to the furnace also affects the temperature measurements, and the same applies in a lesser degree to temperature determinations of the gases at different points within the setting.

C. D. Young. In some recent work with superheater locomotives we have found that generally the superheat will increase with increased evaporation or increased burning rate of the boiler. This is confirmed in stationary practice, I see, by the conclusions drawn in Par. 21. The diagram which illustrated this, however, has the line curved in the upper right hand corner, whereas our tests with a superheater applied to water tube locomotive boiler seem to indicate that the line should be straight; that is, the increase in superheat is almost directly proportional to the increase in the burning rate.

A question which we have before us just now in locomotive practice is the determination of the effectiveness of water and superheating heating surface in a boiler and I would like to know if Mr. Bump has data to show what the heat transference rates are as between the flue gases and the water and the flue gases and the steam. Our results seem to indicate that the superheater heating surface *per se* is only about half as effective as the water heating surface in heat transfer.

The Author. Professor Ennis has made the statement that "as large a heating surface as was provided should have more completely absorbed the furnace heat." I would call his attention to the last two columns of Table 3 which show that there was very little difference between the temperatures of the gases leaving the boiler and the saturated steam in the boiler. The temperature of the fluid within the tubes is the minimum limit of the exit gas temperature, and no amount of heating surface will reduce this limit.

The difference between the efficiencies at half load and full load was more than 3 per cent, not about 1½ per cent as Professor Ennis has stated. This means that the boiler running at full load would waste 0.5 tons of coal per horsepower-year, instead of the 1/5 ton stated in the discussion.

Although there is fuel economy in running at half load, yet fuel economy is not all there is to the cost of steam.

These tests are not put forward to show that the cheapest steam is to be obtained at low boiler rating. This would only be true with a very high priced fuel. With the usual prices of coal, and interest and depreciation taken into account, this boiler would need to run at 150 per cent rating at least, in order to generate steam at the lowest cost.

In reply to Mr. Young relative to the superheat curve of Fig. 2, the points obtained by these tests as well as from a later series of tests made after the baffles had been removed indicate that the line should be a curve, not a straight line. In other words, the superheat did not increase so fast as the boiler rating. The fact that the superheater was too small for the quantity of steam generated at the highest ratings may have had some influence upon the superheat.

In regard to the relative rates of heat transfer in the superheater and in the boiler, we have no data that will give an absolute measure of this transfer, but can get an approximate comparison from the drop in temperature of the gases as they pass over the several surfaces. Making calculations on this basis, we find that the rate of heat transfer for the superheater is fully as great as for the adjacent portions of the boiler tubing.

AXIOMS CONCERNING MANUFACTURING COSTS

By Henry R. Towne, Published in The Journal for December 1912

BRIEF

In a paper entitled The Enginner as an Economist, contained in Volume 7 of the Transactions, 1886, by the present writer, is the following statement:

"To insure the best results, the organization of productive labor must be directed and controlled by persons having not only good executive ability, and possessing the practical familiarity of a mechanic or engineer with the goods produced and the processes employed, but having also, and equally, a practical knowledge of how to observe, record, analyze and compare essential facts in relation to wages, supplies, expense accounts, and all else that enters into or affects the economy of production and the cost of the product."

The following paper attempts to sum up the results of modern experience in these matters, and to state the views now generally held concerning the fundamental principles which underlie industrial accounting. The conclusions reached are embodied in the Axioms; the arguments on which the latter are based are contained in the intermediate text.

DISCUSSION

Arthur C. Jackson. I wish to point out a different procedure from the one suggested by the author in Axiom 9. If the interpretation of the author's statements and the arguments I wish to present for consideration can be accepted, a somewhat different result than that which has in the past been generally acknowledged correct will have to be considered.

If in Par. 12, " production and selling are two separate and distinct processes " (and I would be willing to differentiate still more decidedly between them and call them separate and distinct functions), is there any reason for distributing commercial expense upon the bases of shop costs?

The statement in Par. 11 advocating the elimination of material

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

from the basis of distribution of non-productive or manufacturing expense on account of its varying value should lead to the elimination of this variable component from the basis of distribution of commercial or selling expenses. This leaves only two bases upon which commercial or selling expenses may be distributed, productive labor or selling prices.

Inasmuch as "producing and selling are two separate and distinct processes," does it not appear that the total selling expense should be distributed upon the basis of sales, just as the total of all expenditures incident to, and not an element of, the production or the product, are distributed upon the basis of productive labor?

Is it not often the case that the selling price of the manufactured product remains more uniform than the prices of the materials entering into its manufacture; and that the selling price is much more affected by market and trade conditions than by variations in factory costs?

It is always the ideal of the efficient works manager to get out an ever increasing production with an improvement in quality and a reduction in costs. Likewise it is the object of every sales manager constantly to increase the volume of sales, increase the profit and reduce the proportionate selling expense.

Is not, therefore, the total value of sales the proper basis for the distribution for commercial or selling expenses? This is where the principle that an article can have but one cost fails and so may my argument, but I submit it for consideration because I believe it to be convenient, especially where we have to compete in export markets with foreign competition at a lower price.

If my mthod of determining cost by basing commercial or selling expense upon the sales instead of upon the manufacturing cost could be accepted and used it might result in less oppression of the American manufacturer by the departments of justice and internal revenue and tariff boards, as we could then *show* that goods sold in export markets at a price below the domestic actually have a lower cost than goods sold in the domestic markets at a higher price.

Augustus Smith. The title of Mr. Towne's paper, Axioms Concerning Manufacturing Costs, does not at once suggest the full scope of the paper. We want to know the final or "actual cost," as Mr. Towne puts it, to know what to charge for our product as well as to analyze and study all the various elements that go to build up the cost in order to improve and make more efficient the other departments of a business after the manufacturing department has done its best.

In addition to all this, we want to know what is our actual profit in order to pay proper dividends or to settle equitably all claims based on the cost or on a share of the profits. By a provision of the Payne-Aldrich bill passed August 5, 1909, manufacturing corporations are required to report to the Internal Revenue Bureau what their annual net profits are, and are required to pay a tax on any such profits that are in excess of $5000 per annum.

Thirty-four or more states have passed legislation authorizing a federal income tax. The difference between apparent, estimated or scientifically determined profits will soon make a difference in the taxes we have to pay as individuals.

The writer hopes that the society will take steps to have the subject treated by Mr. Towne investigated by a committee under his guidance with a view to reporting upon a method for computing costs that will be generally accepted as standard

a For paying dividends
b For settling claims based on a share of the profits
c For paying for or receiving payment for work done on "cost" plus a percentage or "cost" plus a fixed sum
d For paying income taxes.

There is no standard practice now. There is no room for bitter disputes on any of the above calculations.

On the back of the blank which the writer's corporation filled out for the Internal Revenue Bureau are printed instructions as to how income shall be determined. This is an extract:

> 16. The gross income of mercantile corporations should be ascertained in the following manner: From the sum of the total sales during the year plus the amount of the inventory at the end of the year deduct the sum of the inventory at the beginning of the year plus the cost of goods and materials purchased during the year. To this difference add the income received from any other source, and the result will be the gross income to be reported under item No. 3 of the return.
>
> 17. The gross income of manufacturing corporations should be ascertained as in No. 16 except that the cost of manufacture should be included in the deduction to be made from the sum of the sales made during the year and the inventory at the end of the year.

It is only necessary to point out that in many businesses the execution of orders taken or sales made in one year may extend far into the next year or the year thereafter to show that the method of accounting suggested by the government does not in all cases show the correct income of a corporation in the sense probably intended by the act.

The method which Mr. Towne has suggested of keeping separate account of the surplus has a direct bearing on this question. For instance, a firm's receipts in one year might far exceed the disbursements, due perhaps to deferred payments coming in or to the cumulative or fortunate result of advertising or of previous soliciting or what not, and without an accepted system of surplus accounting, such a firm might be mulcted for a heavy tax to the government or might have to pay out large sums to parties interested in a "share of the profits," notwithstanding the fact perhaps that for several years previously the firm had been apparently steadily losing money and might expect deficits again for the next few years.

The cycle of planting, cultivating and harvesting in a manufacturing business is not necessarily coincident with the calendar year, and the status of such a business cannot be shown properly at fixed yearly periods without a surplus and shortage account. If a business had to borrow money for several years before revenue began to come back, any funds so borrowed should be repaid before any profit could be declared. Just so with the surplus and shortage account.

The writer does not quite follow Mr. Towne in the matter of interest. Interest on borrowed capital which the author classes as part of the profits seems to the writer to be more conservatively considered as an expense and part of the cost. A sharp distinction can be drawn between interest and other forms of profit. Interest on borrowed capital has to be paid whether or not there is any profit in the business. The stockholders may levy an assessment or borrow more money to pay it, but pay it they must or turn over the business to a receiver.

The author cites two profitable businesses, one where *A* puts in $200,000 as capital while in the other *B* puts in $100,000 as capital and borrows $100,000 at 5 per cent. Each makes $20,000 which is 10 per cent on *A*'s capital while *B* divides his $20,000 of profit into 15 per cent on his capital and 5 per cent interest on his borrowed money. But suppose each business lost $20,000.

This would be 10 per cent loss on *A's* capital, but *B* would have to pay 5 per cent on his borrowed money just the same and face a loss of $25,000 on his capital or 25 per cent. The fact of the matter is the borrowed capital is not " on the table " in the sense of being exposed to the hazard of the business.

Another way of looking at borrowed money is that many businesses, especially those which the author characterizes as engaged in contract work, have no definite amount of invested capital, in his conception of the term. Such firms take as much business as they can get hold of and then raise the necessary additional capital to handle the business just as they take on extra hands to execute it, and the interest they pay for this capital must be considered an expense the same as are the wages they pay for the extra men and to be deducted before any profit is declared. The writer thinks therefore that Axiom 15 should be amended to read *Interest on Borrowed Capital should be treated as an Operating Expense.*

The object of this discussion, however, is to emphasize the vital importance of Mr. Towne's paper calling as it does for agreement in the method of accounting or the creation of a correct science of industrial accounting. The writer's appreciation of the value of the paper is such that he has hesitated to express a divergent opinion concerning Axiom 15. The main thing is to work for a standard system which can be amended from time to time afterward if necessary. As the author says no standard as to what such words as " earnings " and " profits " mean has as yet been established. Scientific management without scientific accounting is like professional billiardists competing without keeping the score.

WM. KENT. Referring to Mr. Towne's percentage distribution of the several items of cost given in his table in Par. 7, he takes the total cost, including the commercial expenses at 100 per cent and expresses the several items as percentages of that total cost. In my experience as an accountant I have found it preferable to take the factory cost of the goods packed and in the warehouse at 100 per cent, and to express the several items as percentages of that total. By this method the table would be modified as follows:

Nos.	1	2	3	4
L = productive labor	31	24	35	24
M = productive material	42	47	30	48
PC = *prime cost*	73	71	65	72
Me = manufacturing expenses	27	29	35	28
SC = *shop cost*	100	100	100	100
Ce = commercial expenses	11	43	22	28
AC = *actual cost*	111	143	122	128
Total expenses (that is, $Me + Ce$) =	38	72	57	56

The factory cost is the labor, plus the material, plus the factory expense. The factory should make the goods as cheaply as it can and sell them to the selling department either at an agreed price or at some percentage of the factory cost. In a factory in which I was interested we arbitrarily fixed the price to the sales department at 50 per cent of list (we had a list price from which discounts were usually given), and we said that the factory should make the goods for half the list including the factory expense, and the factory should make a profit on them at that price if it could. The selling department should buy the goods from the factory at 50 per cent from the list and sell them for what it could, and make as much profit as it could. The accounts of the two departments, the factory and the selling department, should be kept separate.

The Author. Mr. Jackson's comment on Par. 12 shows that he is in accord with me as to the distinction between production and selling. It seems immaterial whether we call these divisions processes or functions.

He contends that it is not often the case that the selling price of a manufactured product remains more uniform than the prices of the materials entering into its manufacture. Possibly this is true when the product is simple and staple; it is not true, however, as to specialized products, especially those controlled by patents or trademarks, the prices of which frequently remain unchanged for months or years, whereas the prices of the materials from which they are made usually fluctuate weekly or daily.

I do not regard " sales " as a proper basis for the distribution of commercial or selling expenses. In the case of staple products prices fluctuate frequently, sometimes daily, and in the case of nearly all products different prices are charged for the same article at the same time to different classes of customers. The price basis, therefore, is a fluctuating one, whereas the cost basis is substantially constant, the changes in it taking place gradually and infrequently.. I believe that on full consideration of all the factors it will be found that "shop cost" constitutes the most logical, most stable, and most accurate basis for the distribution of commercial expenses.

Mr. Smith suggests that the importance of the subject justifies the appointment by the Society of a special committee to formulate and submit a standard system for computing manufacturing costs. I heartily concur in this suggestion. Already, in several lines of industry with which I am familiar, there is a movement among the manufacturers concerned to bring about a uniformity in methods of cost acounting, in order thereby to promote closer uniformity in quotations. Experience has shown that divergence in quotations is frequently based upon divergence in costs, due in turn to divergence in methods of computing costs. The Society can render no greater service to organized industry than by taking the lead in bringing about a reform in the method of computing costs, and in establishing a standard method for the accomplishment of this vitally important part of the work of industrial management.

Mr. Smith questions the correctness of my views concerning the distribution of interest on capital. He says "interest on borrowed capital has to be paid whether or not there is any profit in the business." This may be true also as to dividends. A dividend is sometimes paid (out of accumulated profits) when it has not been earned, and still more frequently the dividend actually paid represents only a fraction of the profit earned. In both cases the question relates merely to the disposition of profits, and to the different ownership of capital involved. Mr. Smith would amend Axiom 15 to read "Interest on borrowed capital should be treated as an operating expense." To this I must dissent. It is immaterial who owns the capital employed in a business, and whether it is represented by stock, by bond, or by bills payable. All of it should be treated alike for accounting purposes. Either no deduction should be made from profits on account of interest on capital, or else interest should be deducted on the entire amount of capital employed. Any other division would imply differences between the results obtained in one case and in others which would be fatal to the establishment of a standard of comparison.

I endorse unqualifiedly Mr. Smith's closing statement that the main thing is to work for a standard system.

DIMENSIONS OF BOILER CHIMNEYS FOR CRUDE OIL

AT SEA LEVEL AND AT VARIOUS ALTITUDES, WITH CORRECTING FACTORS FOR FUEL ECONOMIZERS

BY C. R. WEYMOUTH, PUBLISHED IN THE JOURNAL FOR OCTOBER 1912

ABSTRACT OF PAPER

Chimney tables applicable to boiler plants using coal fuel give dimensions larger than necessary for oil fuel. It is impossible to compile a single table of correct chimney capacities applicable to different types of boilers, operating conditions, etc., for oil fuel.

This paper sets forth the elementary principles for the determination of the dimensions of chimneys, with special reference to the use of crude oil; it also presents data regarding the draft necessary for burning oil under Babcock and Wilcox boilers of various sizes, at various ratings, and a table of chimney capacities applicable to certain sizes of Babcock and Wilcox boilers.

The operating fuel economy of a crude oil plant is largely influenced by the excess air supply due to excessive draft, and the author recommends the use of lower chimneys than customary, particularly for uniform load plants, not subject to overload, as affording a means of chimney regulation of fuel economy.

Errors are shown in previously accepted formulae for variation of chimney proportions for operation at different altitudes, and correct formulae are given.

Data are given regarding the frictional resistance of fuel economizers, and a table presented showing ratio of reduction of chimney capacity, due to cooling of gases within economizer, and the resistance of economizer. Dimensions of steel chimneys are given for minimum first cost, and selection of type of chimney suitable for quick starting reserve plants is discussed.

DISCUSSION

WILLIAM KENT. In regard to what Professor Jacobus had said as to oil burning, the writer had an opportunity to make

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Presented at the Annual Meeting, December 1912, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th Street, New York. All discussion is subject to revision.

a test with a Scotch marine boiler having four furnaces, each with one oil burner. The test was under forced draft with the furnace and ashpit doors closed so that the flame could not be seen; one of the burners got out of order and smoked badly for a long time before its condition was discovered.

It appeared that when more than one burner was in use, one of them might be running with too much air and another with too little, both giving poor economy, while the average flue gas analysis would indicate that the air supply was just right. The writer was looking for an apparatus resembling a steam gage, with a pointer to indicate the percentage of oxygen in the chimney gases, and asked if anyone knew of such. If the combustion chamber and flues beyond it were so divided that each section of the chamber were fed by one burner, the indicator would show whether or not each burner was working under ideal conditions. The condition of successful operation of either oil or coal-burning furnaces was, as far as he was able to find, that the oxygen in the gases should be between 3 and 5 per cent, hot air would uselessly be carried out of the chimney. The apparatus he wanted would tell him when he had between 3 and 5 per cent of oxygen in the gas.

E. H. Peabody referred to Mr. Kent's remarks that it is possible to have two burners in operation, one with too much air and one with too little. The furnace under consideration is designed to take care of a poor mixture, and it is quite possible to take care of any irregularities of that kind; but of course it is a mistake for one burner to get too much air as that can be regulated. The importance of furnace in oil burning is much greater than that of the burner.

D. S. Jacobus. Mr. Weymouth will naturally answer the questions that have been asked about his paper, but I might say that Mr. Kent's idea of determining the oxygen component in the flue gases in place of the carbon dioxide is a feature that is not as important as the accurate determination of the carbon monoxide. Mr. Kent says that 3 per cent of oxygen is a good amount in oil burning, but this is not all that must be strived for, as with 3 per cent of oxygen a poor furnace may allow considerable carbon monoxide to escape to the stack, whereas with a good furnace there would be no carbon monoxide, or at best not over one-fifth of one per cent.

The Author. Mr. Kent's discussion refers to the question of oil burning, rather than directly to chimney capacities, which is the subject matter of this paper. It appears that Mr. Kent has been fully answered by Dr. Jacobus and Mr. Peabody.

In view of the recommendations in this paper in favor of low chimneys for boilers operating at uniform load, it is advisable to repeat a well-known caution in regard to the effects of downward currents of the air during high winds when the chimney is unfavorably situated in respect to surrounding buildings, hills, etc.; with a low chimney the loss of draft from this cause is more pronounced than with higher chimneys. Based on the formula for pressures due to wind velocity given in Kent, the writer has computed the corresponding pressure in inches of water for various velocities as follows:

Wind Velocity, Miles per Hour	Equivalent Pressure, Inches of Water	Condition of Wind
1	0.0005	Hardly perceptible
2	0.002	Just perceptible
3	0.0044	
4	0.0078	Gentle pleasant wind
5	0.0122	
6	0.0176	
7	0.0176	
8	0.0239	Pleasant brisk gale
9	0.0395	
10	0.0489	
12	0.0705	
14	0.0955	
15	0.11	
16	0.125	
18	0.159	Very brisk
20	0.195	
25	0.306	
30	0.447	High wind
35	0.6	

These pressures are realized on a plain surface at right angles of the direction of the wind. The vertical component of wind velocity would be effective only in the case of boiler chimneys.

Since the preparation of this paper, data have been secured on a rather interesting oil burning plant, the results of which appear to be quite ideal. The plant in question is the Sloat Boulevard Pumping Station of the Spring Valley Water Works, San Francisco. There are installed two Babcock & Wilcox boilers, each rated 152.5 h.p. There is also installed a Green fuel economizer having a total of 16 sections, each containing six tubes 4 in. in diameter. The whole is connected to chimney 66 in. in diameter, having a top height of 35 ft. above boiler room floor line.

The chimney has a relatively large diameter for the work and the draft loss by friction is therefore minimized. There is one right-angle turn from the boilers entering the economizer with a straight pass from the economizer to the chimney, except a right-angle turn in passing upward into the chimney.

The station records of water and oil measurement indicate that the boilers operate at about 10 per cent above rating, one boiler only being in service at a time.

In order to obtain sufficient air for combustion, it is necessary to keep wide open the front ashpit doors, rear boiler damper and stack damper. While no observations were made of the gas analysis, it appeared that combustion was proceeding with the usual minimum air supply and without smoke. If such is the case, it is apparent that when operating at this load, the most negligent fireman could not materially increase the air supply for combustion, because all air doors and dampers are wide open and there is no means of increasing the draft.

The author has suggested for trial purposes, the further reduction in stack height by the removal of one course of steel, but this has not as yet been tried. The writer knows of no better example than this for the regulation of boiler efficiency by stack height; such regulation, however, is limited to plants operating under practically uniform load conditions.

CASE CARBONIZING

By Marcus T. Lothrop, Published in The Journal for December 1912

ABSTRACT OF PAPER

The case-carbonizing process requires an increasing of the carbon content of the surface of the material treated while the original composition of the interior is retained. It is essential that the details of the operation be understood to secure uniformity of product, and these researches were undertaken with the object of determining the causes of irregularity and the precaution which must be employed to secure uniform results.

The experiments undertaken were to determine:

a The effect of heat treatment in case-carbonizing steels upon the physical properties of the metal.
b The effect of temperature used in case carbonizing.
c The effect of heat treatment after case carbonizing.
d The effect on the rate and depth of carbonization of the composition of the steel being case carbonized.
e The efficiency of case-carbonizing materials.
f The rapidity with which heat is conducted through carbonizing materials.

The conclusions deduced in each case are listed in the body of the paper under the headings corresponding to the several experiments, and the detailed results of the experiments are tabulated for further reference in the appendices

DISCUSSION

Albert Sauveur.[1] Those interested in the case hardening of steel will be greatly indebted to Mr. Lothrop for his extensive investigation of the subject and for the simple manner in which his results and conclusions are recorded. These results on the whole agree closely with our present understanding of the case hardening operation. We have realized for some time that careful heat treatments were needed after carbonizing in order to

[1] Prof. of Metallurgy and Metallography, Harvard University, Boston, Mass.

Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

confer a fine structure both to the core and to the case. It was not so generally known, however, that the strength and toughness of the case-hardened article could be further increased by tempering. It is the writer's opinion that little is to be gained by tempering case-hardened articles for the following reasons:

"There seems to be at first sight no apparent reason why case hardened articles could not be likewise improved by suitable tempering following the hardening of the case. On second thought, however, it will be realized that since the chief purpose of tempering is to toughen the hardened steel and since hardened articles depend for their toughness on the toughness of their cores little is to be gained by tempering them."[1]

Referring to the exhaustive tests which the author conducted in order to ascertain the relative merits of various carbonizing materials, it is somewhat disappointing that he fails to give the names of the various substances investigated. The reasons for the author's secrecy in this matter are not readily understood. Referring to material No. 14, the writer infers from its composition that it consists of a mixture of charcoal and of barium carbonate and notes that the results obtained by its use are very satisfactory. This confirms his own experience with this kind of material.

J. A. Mathews[2] said he had watched the progress of the work described in this paper during the two or three years that it had been going on with a great deal of interest. He had had personally but little to do with the paper, which represented the work not only of Mr. Lothrop and his assistants on the steel making side, but also considerable work of the metallurgical staff of the H. H. Franklin Manufacturing Company and the Brown-Lipe-Chapin Company, both of which had done large amounts of case hardening. The paper was of extreme value, and virtually reduced case-carbonizing to a science. By following the directions and observing the results as given in the paper, it would be possible to do case hardening with an extreme degree of accuracy in duplicate parts. That was something that had not always been done. One of the most important points covered by the paper was in relation to the thermal conductivity of the different compounds. That was something that should be known regarding all the different compounds, particularly in the case of changing from one to another where the mere change due to the difference of thermal conductivity of the material in the box would affect the total penetration of the carbon in a given time or at a given temperature. But if the relative conductivities were known such differences could be prevented. Such data had not been available in the past. Mr. Lothrop and his collaborators in this work were entitled to great praise for the thoroughness with which they had carried on this investigation.

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[1] The Metallography of Iron and Steel, Albert Sauveur, 1912, Lesson 16, p. 6.

[2] Genl. Mgr., Halcomb Steel Co., Syracuse, N. Y.

Robert R. Abbott.[1] The meaning of the author in many places is obscure. For example, Appendix No. 1, test No. 1, treatment was given as quenching from the pot at 1500 deg. To make a legitimate comparison of this test with tests Nos. 2 to 12 it should have been carbonized in the same furnace and cooled under identical conditions with them. Were the pots removed from the furnace to cool? The carbonized temperature is given at 1700 deg. Then how was this No. 1 test quenched at 1500 deg.? How was this 1500 deg. measured? In the summary at the bottom of Appendix No. 1, Table 12, the best single treatment is given as quenched from 1600 deg. (test No. 4) and yet test No. 1 quenched from pot at 1500 deg. gives a higher rupture load (900 against 850) as well as a better deflection (0.40 in. against 0.24 in.).

In Appendix No. 1, Tables 13 to 21, under Summary 1 is stated "Strength and toughness decreases with increasing depth of case." This is an example of a common error into which many investigators are led. It is a conclusion based upon insufficient or faulty experimental data. The expert investigator eliminates all variables but one. In this case two variables were present, first, a variation in the depth of carburization and, second, a variation in the *correct* heat treatment, since the different depths of carbon undoubtedly had different percentages of carbon at the surface and the treatment should have been changed to suit the different conditions; instead of this the same temperature was used for all depths. For example, Table 13, Treatment 1: if 1500 deg. produces a certain condition in the case with a depth of 0.01 in., will 1500 deg. produce the same condition when the case is 0.02 in. The writer has not considered this point in drawing his conclusions.

Appendix No. 1, Table 16, Summary 4: The best double treatment is given as 1600 oil—1500 oil, while from the tables this is not as good as 1600 oil—1500 water. In general the writer questions many of the conclusions of the author as given in his summary. For example, comparing Table 16, treatment No. 14 with treatment No. 17, the use of 1500 deg. for the second quench has increased the load from 1240 to 1390, or 12 per cent, while the deflection is decreased from 0.75 in. to 0.44 in. of 41 per cent. There can be no question but that the author has not drawn correct conclusions; 1600 deg. oil—1300 deg. oil is by far the better. A shock test would show this. For the same reason the author's conclusions in Par. 7 *f* are incorrect.

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[1] Metallurgical Engr., The Peerless Motor Car Co., Cleveland, O.

In Table 19 the author's best double treatment, namely, 1500—1400 is in reality but a single treatment as the final quench (1400 deg.) is about 20 deg. above the upper critical temperature of the core and therefore both the core and case are in the solid martensitic condition, which is absolutely wrong from a theoretical as well as a practical standpoint.

Considering the author's conclusions regarding the best single and double treatment for different carbon nickel steels:

	Best Single	Best Double	
0.10 Carbon................	1500	1600	1500
0.15 Carbon................	1500	1600	1500
0.20 Carbon................	1450	1600	1400
0.25 Carbon................	1500	1550	1400
0.31 Carbon................	1400	1500	1400

Why should there be such a drop and then a rise in the best single treatment at 0.20 and 0.25 carbon? Why should the best double treatment have no variation in the best treatment, for the 0.10 and 0.15 carbon and also for the 0.20, 0.25 and 0.31, but vary 100 deg. between the 0.15 and 0.20 carbon? This is manifestly not probable.

In general the value of the experimental data, given in Tables 12 to 21 inclusive, is questionable as this work represents a series of hit and miss treatments with no evidence of a fundamental knowledge of the theory upon which correct heat treatment is based. This is particularly evident in the so-called double treatments, many of which are in reality not a true double treatment, i. e., one in which first the core and then the case is affected.

Particular attention might be called to the fact that many of these treatments could have been improved if the oil and water quenching had not been indiscriminately used. An oil treatment does not affect the case as deep as a water treatment. In other words, an oil treatment, if done at the right temperature, leaves the steel in a condition similar to a steel carbonized to a less depth, but water treated. Briefly then many of the author's results with oil treatment could have been duplicated by a water treatment with a shallower carbonization and therefore with a saving in cost.

The conclusions given in Par. 11, when taken in connection with the temperature given for the best single and double treatments, particularly of steel No. 7, have not been made with due regard for experimental evidence offered. They are incorrect.

Par. 33 *d* is too broad a statement, since the presence of needles of cementite is not caused entirely by high temperature as this can also be produced by a longer time of carbonization at a lower temperature.

The statements in Par. 33 *g* cannot be condemned too strongly in view of what is one of the most important and fundamental operations in the scientific heat treatment of carbonized steel. If the steel has been correctly treated subsequent to carbonization the excess cementite will not exist " in the form of film of carbide between the grains of the metal " as the author states. If the practical man was unable to take advantage of the better wearing surface produced by a carbonization of greater than 1.00 per cent surface carbon without the danger of " rendering it liable to fail by flaking off or spawling " he would certainly be behind the times in these days of rapid increase in the knowledge of heat treating. The above statement also applies to Par. 47 *e*.

The explanation in the second part of Par. 33 *h*, as has been so ably given by Dr. H. M. Howe, is taken by the author as a reason for the flaking off of the case from the core. While this tendency is undoubtedly present if the material is not subsequently given a correct heat treatment, many practical casehardeners can carbonize an open hearth steel at say 1750 deg. in the proper material and then by a correct heat treatment make it as efficient to resist flaking off as could be done by carbonizing at 1650 deg.

In the third part of this paragraph stress is laid upon the coarsening of the grain size by high heat. This is of little practical importance as correct heat treatment will break up any grain produced during the process of carbonization.

Uniform results cannot be obtained by the repeated use of carbonizing material for high-grade work as advocated in Pars. 47

and 48. Mixing part old and part new is not desirable as the old material generally is not uniform, having been used for different lengths of time and at different temperatures.

Benj. E. Bosler[1] presented in a written discussion some notes on case hardening. The parts were case hardened at No. 1 Smith shop. About 700 or 800 bevel and spur gears for mill roller runs have been treated during the past three years, varying in size from 10 in. to 18 in. pitch diameter and about 4 in. to 5 in. width of face. Practically all crane and motor pinions are now case hardened and a few spur gears as large as 30 in. in diameter by 8 in. face have been treated.

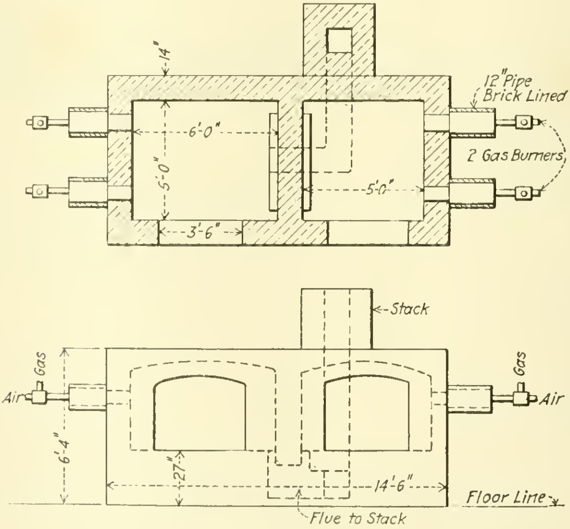

Fig. 31 Furnace for Case Hardening. No. 1 Smith Shop

About 90 per cent of the case-hardened gears are made from open hearth steel forged blanks of dead soft stock with carbon between 0.8 and 0.12 per cent. The company has case-hardened steel with a carbon content as high as 0.20 per cent but finds that the best results are obtained by using steel with carbon under 0.12.

The other 10 per cent of the gears treated are steel castings made to the following specifications: carbon 0.10 to 0.15 per

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[1] Asst. Supt. Mech. Dept. Cambria Steel Co., Johnstown, Pa.

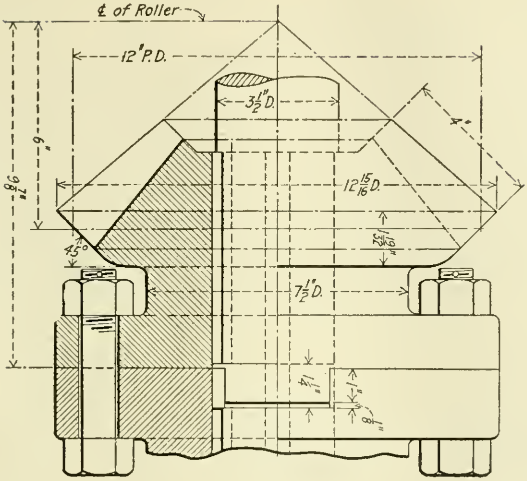
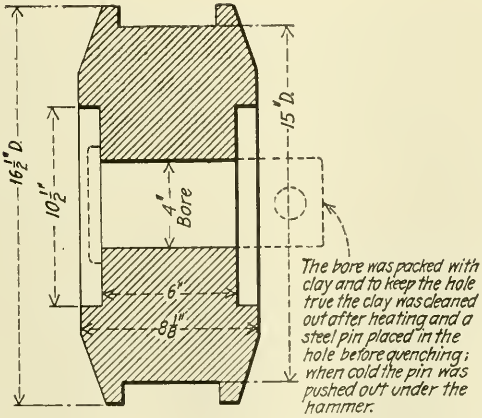


Fig. 32 Half Coupling with Mitre Gear, No. 1 Mill Furnace Run; 0.12 Per Cent, Carbon Steel; Case Carbonized on Face and in Bore and Keyways. Penetration, ⅛ in.



The bore was packed with clay and to keep the hole true the clay was cleaned out after heating and a steel pin placed in the hole before quenching; when cold the pin was pushed out under the hammer.

Fig. 33 Case-Hardened Roller for Ore Screening Plant. About 30 Hours is required for $\frac{3}{16}$ In. Penetration

cent; sulphur not over 0.05; phosphorus not over 0.04; silicon 0.15 to 0.30; manganese 0.60 to 0.80.

Regarding the life of the case-hardened gears, the roller run was installed in front of mill furnace No. 1 about four years ago where about 200 case-hardened gears were used and up to this time not one has been replaced, although the table has had very hard service. Gears in the roller runs leading up to the 18-in. mill, in the roller runs at Gautier 24-in. mill and in the tables at the Franklin mills, are giving equally good service.

Among other parts case hardened are bushings for roller bearings (ground after treated); links and chains for conveyor chains (very light penetration, about $^1/_{64}$ in.); and valve motion parts and connecting rod slides for locomotive repairs.

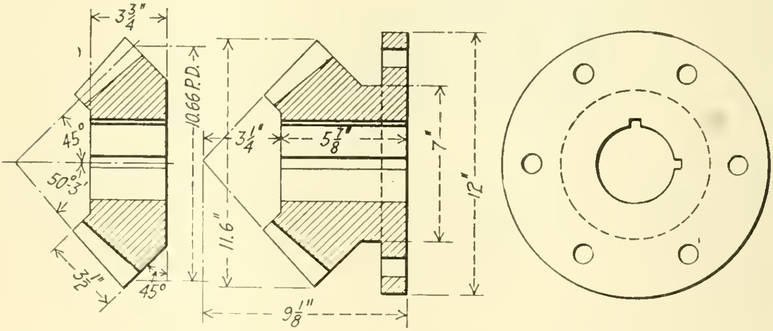


FIG. 34 GEARS FOR 24-IN. MILL TABLES; FORGINGS, 0.08 TO 0.12 PER CENT, CARBON STEEL. ABOUT 24 HOURS REQUIRED FOR ⅛ IN. PENETRATION

The gears or other parts to be treated are placed in round or square boxes and packed with bone black, using about three-quarters old to about one-quarter new material. The boxes are then sealed with clay and placed in the furnace where they are heated by natural gas to a temperature of about 1800 deg. fahr. The time required to heat properly varies from 12 hours to 30 hours, depending entirely on the size of the parts being treated and the amount of penetration desired. A great amount of the work requires about 20 to 24 hours from the time the furnace is lighted until the charge is ready to be withdrawn and quenched. This will give about ⅛ in. penetration which is the depth reached on most of the gears.

On light work the charge is usually allowed to cool before it is taken out of the carbonizing material when it is reheated to about 1400 deg. fahr. and quenched in water. Nearly all of the gears and other heavy work are quenched in water direct from the packing box, a method which gives very good results and saves the cost of reheating. The heat in the gear at the time of quenching in this case is also 1400 deg. fahr. as near as the operator is able to judge with the eye.

It is found necessary to grind the bores of all gears after hardening as the bore is usually slightly out of round.

Boxes made of 1 in. plate steel will last for about 15 times in the furnace before they become too thin from frequent scaling.

The furnace used is of very simple construction, with two heating chambers each being supplied with two natural gas burners. No trouble whatever is experienced in maintaining an even temperature of 1800 deg. fahr. throughout the time the charge is in the furnace. The time required to bring the cold charge up to this temperature requires from 4 to 6 hours.

A diagram of the furnace used is shown in Fig. 31, and drawings of the pieces case hardened in Figs. 32 to 34.

The Author. I desire to thank Mr. Benj. E. Bosler, Dr. Albert Sauveur, Dr. John A. Mathews and Mr. Robert R. Abbott for their kind discussions of my paper.

INVESTIGATION OF EFFICIENCY OF WORM GEARING FOR AUTOMOBILE TRANSMISSION

By Wm. H. Kenerson, Published in The Journal for September 1912

The paper describes a series of tests made to determine the efficiency of three types of worm gearing intended for use in automobile transmission, and at the same time a series of tests to determine the effect of continuous running Data regarding the shape and construction of the gears are given and the results tabulated and also expressed in graphic form. The results indicate a high efficiency and large carrying capacity.

DISCUSSION

Elmer A. Sperry. Question was raised as to the correctness of the evidence contained in the paper that the coefficient of friction decreases with increase of pressure. Within the past year the writer has conducted some interesting experiments on two large gyroscopes with oil bearings and running up to about 50 ft, per sec. with loads varying through a range of about 3000 per cent upon the lower half of the bearing and more than this on the upper half. Upon the lower half of the bearing the actual load ranged approximately from 2200 lb. to 65000 lb., whereas on the upper half of the bearings the load varied from zero to 60000 lb. This pressure could be applied at will, practically rising and falling in the form of a sine curve between the minimum and maximum.

The coefficient at gravity load was about 0.008, and for the highest load about 0.0036 to 0.004, as nearly as it can be determined. The writer's experience has invariably been that as the pressure would increase the coefficient would come down under the conditions named, the apparent range being somewhat in excess of 100 per cent. The results being entirely concordant and dealing as they did with large quantities, they may be con-

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

sidered as reliable and possibly contributing farther to our knowledge on this extremely important subject.

The remarks of Mr. Kent regarding the area of contact between worm and wheel being unknown as to influencing the coefficient of friction are not quite appreciated. Is it not possible the efficiency would be quite independent of the area actually involved? For instance, in journals above referred to, which were ordinary oil bearings provided with excellent oil circulation employed for the twofold reason of lubrication and cooling, it was observed that after 160,000 precessions of these gyros, involving very heavy pressures on the journals, that there was an entire lack of evidence of metallic contact or even that only a small portion of the entire area had ever been involved in sustaining these loads. For instance, one photographic record shows that only about 20 per cent of the projected area had ever been employed in the actual work as the original tool marks are present over the remaining surfaces.

W. C. Marshall. I would ask why the efficiency increases with the increase of load and speed, and why it is greater on the first and second speeds than on the direct drive. In the case of first and second speeds other gears are introduced and the efficiency should be less. In some cases it is greater with other gears introduced than with the direct drive. The rubbing velocity at lower speeds is less, but Mr. H. Kerr-Thomas of the Pierce-Arrow Company definitely states that in all his tests the efficiency does not vary appreciably between low and high speed with varying loads. The efficiency depends on the frictional resistance which varies with the square root of the velocity, and inversely as the pressure on the teeth. With an increase of pressure on the teeth and the velocity uniform there would be a reduced coefficient of friction. But if the velocity is increased and the pressure uniform the numerator of the frictional coefficient will be increased and consequently the resistance. If both quantities are varied (the denominator and the numerator) the result will remain nearly constant. Of course, this does not apply to extremely high speeds.

In the author's tests, however, the efficiency decreases in several cases with increase in load and speed, which I do not understand. It seems to point to the destructive coefficient which comes into play at high speeds and large loads. This coefficient is the product of the pressure and the velocity and the tendency is for it to cause heating, which is shown in these experiments, as the oil becomes thinner and allows metallic contact, which reduces the efficiency.

It seems to me that the coefficient of friction in these experiments is rather high for a large load, as indicated by the rising temperature of the oil, and I have made one or two calculations to find out what this coefficient was, taking the figures given in the first line of Table 1. From the specific heat of the oil, the weight of the oil, and the number of heat units given to this oil in 6 minutes, I find 131 B.t.u. were given to the oil in 1 minute. Substituting that in the expression $H = \frac{p\mu V60}{J}$ for heat units in terms of the pressure, coefficient of friction, velocity and Joules' equivalent, the coefficient of friction comes out as 0.033. Working with that coefficient, which is rather large, the efficiency of these gears would figure out as 93 per cent $E = \frac{1 - \mu \cot \alpha}{1 + \mu \tan \alpha}$. It did not figure out anywhere near 93 per cent in this case. If Unwin's recommendation for the coefficient of friction = 0.002 is used in such cases, the efficiency will be in the neighborhood of 0.996. Mr. Thomas uses the same one in making calculations on worm gears, in which case the efficiency comes out at 0.996 per cent, which is a great deal higher than any of the experiments shown in the paper. The angle α or the helix angle is 38 deg.

Bevel gears afford such a high efficiency that it does not seem at all advantageous to use worm gears in driving automobiles unless the noise is a consideration. I would like to know if there was noise in connection with the test on bevel gears. That is an important point, especially if there is any resonant quality to the support.

In a test made on worm gears by Frank Burgess a curve of efficiencies is given which, using small h.p., runs almost in a straight line from 1 h.p. up to 3 h.p., where the efficiency is 93 per cent, then rises in the case of 4 h.p. to 95 per cent, and then begins to drop at a steady rate to 91 per cent at 8 h.p. Professor Kenerson's experiments do not show anything like this. There is no drop; always a rise. But there must be a point where the drop takes place, and I would like to see some results to show it.

The automobile transmission is important and it should be ascertained where the efficiency decreases. Also there must be high efficiency at low speed, since nine-tenths of the time automobiles are running under reduced power, and if the efficiency is very low it does not pay to use worm gearing.

Mr. Kerr-Thomas has proved that under certain conditions, such as trucking, the efficiency is just as high at low speeds as at high. Professor Kenerson does not agree with him at all, and I would like to get an expression of opinion from other members of the Society in regard to this point.

William Kent said he would like Mr. Kenerson to give some theoretical reason why at uniform speed of rotation and increasing pressures. and consequently increased horsepower, the efficiency increases. It might be possible in starting on low speeds where the worm gears were imperfectly polished, that they were not as smooth as they should be and that the viscosity of the oil was greater at the low temperatures, but it is improbable that either of these causes would be sufficient to account for the lower efficiency at low pressures.

In regard to calculating the coefficient of friction, Mr. Kent saw no way that it could be done, because it was impossible to calculate the area of the surface that is subjected to pressure, that is, the area of contact.

L. B. Taylor. Mr. Kent called attention to the fact that the coefficient of friction has usually been considered to increase with the increasing specific pressure while the experiments in question indicate the reverse.

The laws governing copiously lubricated surfaces as determined by Petroff and given in the Hütte, 1911 edition, Vol. 1, Page 244, are as follows:

The coefficient of friction varies

- *a* directly as the coefficient of the internal friction of the oil used at the temperature prevailing
- *b* directly as the relative velocity of the rubbing surfaces.

On the other hand the coefficient varies

- *c* inversely as the actual mean thickness of the layer of oil between the rubbing surfaces
- *d* inversely as the specific pressure exerted between the contact surfaces

e at constant temperature the thickness of the layer of oil is inversely proportional to the square root of the specific loading of the surfaces in contact.

Since these laws were discovered the specific pressure allowed on steam turbine bearings has been increased 50 per cent.

The Author. Referring to Professor Marshall's remarks, his understanding that the use of speed gears will affect the efficiency is incorrect. The dynamometer is placed between the change gears and the gear under test.

In comparing the results of the Burgess test with those under consideration, it should be borne in mind that the gears were tested under very light loads. Mr. Kerr-Thomas' statement that under certain conditions, such as trucking, efficiency is as high at low speeds as at high, undoubtedly refers not alone to the worm gearing but to the whole machine.

This statement is undoubtedly true because of the fact that the power lost in the tires of an automobile is much in excess of that lost in the transmission, and, of course, decreases with the speed. The question raised by both Professors Marshall and Kent regarding the decrease in coefficient of friction with the increased load is referred to and answered by others in the discussion.

There are so many factors to be considered that I believe it impossible to calculate a coefficient of friction as suggested by Professor Marshall.

Professor Kent's question regarding the reason for increased efficiency with the load is answered by the fact that the friction does not increase directly with the horsepower.

EXPERIMENTS WITH NORTH DAKOTA LIGNITE IN A STEAM POWER PLANT AND A GAS PRODUCER

By Calvin H. Crouch, Published in The Journal for December 1912

ABSTRACT OF PAPER

The North Dakota lignite fields cover approximately one-half of the State, or about 35,000 square miles. According to the State Geological Survey report, there were known to be in 1908 twenty-one workable seams of this coal in the southwestern part of the State, varying from 4 to 35 ft. in thickness and found in from 1000 to 1300 ft. of strata.

In this paper are reported some preliminary experiments showing the physical properties of the coal and the results when subjected to heat and the drying action of air; also two evaporative tests and 18 gas producer power plant tests, in which the coal was used as it came from the mine, except that it was broken so as to be charged easily into the gas producer.

The results of the evaporative tests, though not as satisfactory as could be desired, were interesting and instructive, indicating the possibilities of its use for such purposes and the improvements needed in furnace operation to burn it properly. The producer plant tests were highly satisfactory, showing that the coal could thus be utilized without special treatment and that the gas operated satisfactorily in the gas engine, giving a coal consumption in some of the longer tests of about 6½ lb. of coal as fired per kw-hr. at the switchboard for power available for outside purposes. If the power consumed by the gas scrubber was reduced to as small an amount as possible and the generator had been operated at more nearly its rated capacity, the results would have made a much better showing.

DISCUSSION

A. M. Levin. These experiments are interesting and instructing in so far as they deal with the nature of the fuel in general, and with its evaporative qualities; but in so far as they

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

deal with lignite producer gas they are in no way fair tests of the fuel for producer use. The author himself doubts that they are; and his caution, that doubtless under more favorable conditions better results could have been obtained, may serve to offset to some extent the unfavorable impression the extraordinary test figures are bound to give.

One fact which the evaporative tests bring out is that under the boiler the lignites are only the poorest kind of fuel for the reason, if for no other, that they call for something like twice the boiler capacity any ordinary steam coal would require. Another fact about the lignites which the experiments fail to bring out is that as producer fuel they are ideal. Some lignites have proved to be and others, that as yet have not, should be given a fair trial. The chief object with the gas producer is, or should be, the handling of poorer grades of fuel among which the lignites must be counted.

Of the 18 producer tests of the Grand Forks' series there is but one that shows a reasonable fuel consumption per unit output. Mr. Crouch generously puts the blame for the shortcoming of the tests on a presumed inexperience of the experimenters; yet it seems entirely more likely that the blame should be laid to the employment of a wrong type of gas generator. There is not the slightest doubt but that the down-draft principle is wrong with respect to lignite fuels. These fuels, as the experiments bring out, disintegrate when heated in the fuelbed, so that by the time they reach the hearth of the generator they are very fine. When, therefore, in the down-draft producer the fine fuel becomes intermixed with the ashes which form in the greatest quantity at the top of the fuelbed, it should naturally be expected that the bed would become somewhat compact. Consider for a minute that all the fine loose particles in the fuelbed act in the way of so many small valves that tend to seat themselves over the interstices between the grains of fuel and it must be evident that to draw the gases downward in the direction in which these valves close is wrong. Instead, the draft should be upward, in which direction these valves can lift.

Unfortunately, the amount of tar separated in the cleaning of the gas is not recorded. This item would have been interesting for the sake of comparison with what can be accomplished by the up-draft producer in the way of fixing the tarry products of the fuel. However, when some tar will have to be removed from the lignite gas whatever the type of the producer, it would not pay just for the sake of producing a somewhat smaller percentage, to ruin the gas process entirely by adhering to the down-draft principle. An attempt to run the producer so hot as to fuse all the ashes into clinkers would normally result in a leaner gas and a loss of sensible heat in the extremely hot gases. As ordinarily arranged, the power gas producer should be run consistently cool and with a slow current through the fuelbed. There is a time element involved in the breaking up of tarry hydrocarbons as well as in the reduction of the CO_2 gas.

In order to gain a better idea of what can be obtained in the way of returns by the use of lignite in the power gas producer it may be of interest to compare Tests Nos. 17 and 18 of the Grand Forks' series with one of the Bureau of Mines experiments at the Norfolk experimental station on a North Dakota lignite of identically the same quality as the fuels used in these tests; and also with a test on a Washington lignite, which the writer had occasion to make some years ago at Olympia, Wash. This test was fully described in Power[1] and it may be of interest because of the fact that although the fuel was quite high in ash, it proved by the use of a singularly suitable producer to give a high efficiency.

Test No. 17 of the Grand Forks' series is chosen because it is the best of the entire series, and Test No. 18 because it is rather poor, though not the poorest. The proximate analyses of the fuels used in the tests referred to were as given in Table 3, and the results obtained as in Table 4.

In the Olympia and Norfolk test figures allowance has been made for steam supplied to the producers.

The excessively high suction on the gas system of the Grand Forks' plant clearly indicates the real cause of the poor performance of the plant. Of the various losses accountable to this difficulty the following are of importance:

Direct loss due to increased resistance on the engine piston.

Loss due to inefficient combustion and reaction because of excessively high current velocity through the fuelbed, resulting in a lean gas.

Loss due to a reduced engine efficiency because of lack of density of the lean gas in the cylinder.

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[1] December 27, 1910.

TABLE 3 PROXIMATE ANALYSES OF FUELS USED IN TESTS

	Fuel	Moisture	Volatile Matter	Fixed Carbon	Ash	Heat Value per lb., B.t.u.
Grand Forks, Tests Nos. 17 and 18....	N. D. lignite	23.35	33.9	38.4	4.35	8400*
Norfolk Test No. 2................	N. D. lignite	39.56	27.78	26.3	6.36	6802
Olymphia........................	Washington lignite	16.2	28.90	32.1	22.8	7560

* The fuel value of this lignite is not given, but it was evidently quite high; an estimate gives about 8400 B.t.u.

TABLE 4 RESULTS OBTAINED IN UTILIZING FUELS IN POWER GAS PRODUCER

	Gas Analysis						B.T.U. per Cu. Ft.	Economy Coal as Fired per B.T.U-Hr.	Gas Pressure, Inches of Water		Tar Per Cent Weight of Fuel
	CO	CH_4	H	O	CO_2	N			Leaving Producer	Entering Engine	
Grand Forks, Test No. 17............	10.62	4.2	18.97	3.8	6.08	56.25	152.7	2.8	−4.7	−26.9	....
Grand Forks, Test No. 18............	11.70	4.77	8.04	3.7	8.59	63.18	115.4	3.47	−7.5	−28.8	....
Norfolk, Test No. 2.................	20.90	4.85	14.33	0.23	8.69	51.00	188.5	2.23	2.1	0	3
Olymphia...........................	17.2	4.70	24.70	0.6	11.2	41.6	184	1.75	−1.75	− 2	7/8

Loss because of a highly increased power requirement in cleaning the rarified gas.

The excessive suction caused evidently also a considerable leakage of air into the gas system. This, however, may only apparently have affected the heating value of the gas.

The Washington fuel gave a perfectly clean ash, entirely free from coal or clinkers, but the North Dakota fuel used in the Norfolk test is reported to have clinkered some. The cause may have been that the producer, in order to maintain a full load on the engine, was run somewhat above its capacity. Naturally a lean coal, as lignite, will require a somewhat greater producer capacity than a richer fuel.

The Author. I appreciate the generous remarks of Mr. Levin, but I firmly believe that a more experienced person would have secured better economic results in the producer gas tests. It is not claimed in the paper that the suction down-draft producer is the type of gas generator best suited to the utilization of North Dakota lignite. Before installing this experimental unit in 1910, I secured information and advice from a large number of gas producer manufacturers, and found but very few who made producers in capacities of 50 h.p. or under, which they would guarantee to handle lignite satisfactorily. There was no question about large producers of other types handling this fuel, but I wanted a plant approaching in size that which might be installed in a small town or one large enough to demonstrate that the coal could be used in a small isolated plant of the producer gas type. The state of North Dakota has numerous small but rapidly growing towns or villages which are, or soon will be, requiring electric lighting and pumping plants. The problem with them is what kind of a plant should be installed; so that this was regarded as an appropriate problem for investigation in North Dakota. In installing this unit I acted upon the advice given by some of the most prominent gas producer manufacturers, one of whom was at the time experimenting with a lignite producer and who, I understand, has since perfected one, but I am not aware that his company builds them in small sizes.

In connection with the statement that exceptional economic results are not shown, I would state that it was not expected that exceptional results would be secured. I wanted to show that the coal could be utilized profitably in that size of producer, and I believe I succeeded.

As stated in my paper a larger amount of scrub water was doubtless used than was necessary with the result that the power consumed by the scrubber was greater than was necessary. Had this have been reduced to a minimum, the coal consumption per kilowatt-hour available at the switchboard for outside purposes would have been materially reduced.

Furthermore, the refuse which passed through the grate was larger than was necessary, due to unnecessary shaking. This refuse was all considered as waste, while as a matter of fact it should have been recharged into the producer and have been more completely burned. It was not thought wise to do this while conducting the tests, but in subsequent tests this refuse was refired with good results.

There was not enough tar to warrant its being saved. It collected in the bottom of the pit mixed with ash and fine particles of coal which were drawn into the condensing chamber and washed into the pit along with the tar, etc.

Concerning the statement of Mr. Levin relative to the lignite being a poor steaming coal requiring a large boiler, I do not think the tests reported indicate it, but rather that a boiler utilizing this fuel in its furnace needs a large amount of grate surface, a strong draft, and a special furnace adapted to the burning of a fuel rich in volatile matter.

I was not trying to prove that this fuel could be used in a producer gas plant of 250 h.p. or over, for the United States Government had done that, but I wanted to prove that it could be used profitably in smaller sized plants such as might be installed in a small town or manufacturing plant, and in this I think I succeeded.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

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The Editor will be pleased to receive inquiries for further information in connection with articles reported in the review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

American and British engineering papers are from time to time reprinting articles from this Review. In accordance with the policy of the Society, all that is printed in The Journal is free to the entire engineering profession, and all that tends to extend the usefulness of the Foreign Review beyond the limits of the present number of the readers of The Journal is heartily welcomed.

THIS MONTH'S ARTICLES

This month several articles were considered important enough to deserve somewhat longer abstracts than usual: Equivalent Opening of a Ventilating System, by Dr. Kloss, shows that the use of such a method is justified neither by theoretical nor by practical considerations; instead of an equivalent opening, the author proposes to use a resistance coefficient, and derives for a ventilating system a law similar to Ohm's Law. To the same class belongs Dr. Harm's article on a system of testing compresed air machinery, a subject on which, notwithstanding its great importance, extremely little has been published. Mr. Schimanek's article on the six-stroke cycle type of engine is interesting in that it expounds the advantages that can be derived from using cycles of more than four strokes, or moving in a direction opposite to that taken in the early days of the development of the gas engine by Dugald Clark and others. Professor Poeschl's article on the calculation of stresses in rotating discs is, it is believed, the first application to this problem of W. Ritz's principle of variations, on which hardly anything can be found in current engineering literature. Finally, the attention of steam engineers in general and steam turbine engineers in particular is called to the article of Loschge on supercondensation, explaining some apparent contradictions in the phenomena of flow of steam through nozzles which have hitherto baffled such experimenters as Bendemann and Christlein.

In the section of aeronautics will be found a plausible explanation of what is known as an "airhole," as well as a table showing the relation between the speed of an airship and height of sag through an airhole. Air machinery engineers will be interested in data of tests of a German reciprocating compressor plant, as well as a description of its valve gear. A new flue dust catcher is described in the section Firing. It may be mentioned in this connection that while lack of space does not permit giving descriptions of many interesting minor appliances appearing in Europe, an attempt is made whenever possible, at least to mention such as embody a more or less novel principle of operation. New types of stuffing box and of cooling element are described and illustrated in their respective sections, as well as the use of cast-steel rolled flanges for high-pressure piping, a problem which appears to be attracting considerable attention in Germany owing to the growing number of accidents due to failure in flanges in high-pressure piping. The description of compensating pipe joints in the same section will also be of interest in this connection. The Boettcher power counter, really an integrating attachment to a steam indicator giving direct readings of the output of an engine, is likewise described and illustrated.

While considerations of space do not permit as full abstracts as might be desirable, an attempt is made to supplement the information given by means of Supplementary References. to which attention is here directed.

Aeronautics

Resistance of Air and Experiments on Reduced Models (*La résistance de l'air et les expériences sur les modèles réduits*, E. Jouguet. *Revue de mécanique*, vol. 32, no. 1, p. 9, January 31, 1913. 21 pp., 2 figs. *gt*). A general review of the applicability of experimental data obtained on reduced models to the design of airships. The author shows that while in general data obtained from experiments on models may be used for the design of larger types, strict attention must be paid to *perturbations:* (*a*) To correct for the error due to viscosity alone, the experiment on the model must be made at a speed which is to the real speed in inverse ratio of the products of respective densities by the lengths (the law of Osborne Reynolds). (*b*) To correct for compressibility alone, the experimental speed must be equal to the actual; and to correct for both perturbations, as well as for the difference in conductibility, the experiments must be made in air compressed in inverse proportion to the size of the model. This, however, is practically impossible to realize in a laboratory, and therefore it does not appear possible to satisfy at the same time the conditions of both (*a*) and (*b*).

"Airhole" at Landing (*Das "Luftloch" bei der Landung*, E. Heinkel. *Der Motorwagen*, vol. 16, no. 4, p. 91, February 10, 1913. 1½ pp., 1 fig. *ptA*). Airmen usually try to land against the wind, when the relative velocity of the machine with respect to the earth is as low as possible. There is, however, an element of danger in this, because the velocity of the air at the surface of the earth is not the same as at some elevation from it, and the air may be perfectly still at the ground level while at a comparatively slight height there may be a wind of some 10 m (32 ft.) per sec. This is due to the protection afforded the lowest layers of air by the unevenness of the earth surface.

If a flyer runs against a wind of 10 m per sec. with an absolute velocity of 25 m per sec., his relative velocity is 15 m per sec., and when he suddenly enters a stratum of still air, his velocity remains only 15 m per sec., which is not enough for planing; as a result he hits the ground with a thud, having struck an *airhole.* Such airholes may be met, especially in turbulent air, away from the earth surface as well, whenever the ship strikes a region of currentless air surrounded by windy air: in that case, however, the danger is somewhat less, because the ship has time to cross it, and meet the wind again. *In landing* it is, however, always a *safe thing to select a fully open place where there is nothing to keep the wind out.* The only way to protect himself against the airhole danger in landing is to land with the engine throttled, and as soon as an airhole is felt, to start the engine again (this advice should be used with judgment, and only when the airship is not too near the ground).

It is an interesting fact that the height of fall through an airhole is directly proportional to the velocity of the airship. Let G be the weight of the apparatus; v the velocity of the airship in still air; v_1 the wind velocity; h the height of fall. Further, let $v_1=10$. When the ship is in air having $v_1=10$, its kinetic energy is

$$A_1=\frac{G\,v^2}{2g}$$

where $g=9.81$. When the ship passes into the air having $v_1=0$, it loses some of its kinetic energy, which then becomes

$$A_2=\frac{G}{2g}(v-v_1)^2$$

The difference between the values of A_1 and A_2 indicates the kinetic energy A required to bring the airship back to the speed that would allow it to float in the lower still air stratum. In this case $v_1=v-10$, which gives after substitution:

$$A=\frac{10\,.\,G}{g}(v-5)$$

What is wanted, however, is to establish the relation between v and h. When a ship of weight G falls through h, a kinetic energy $A=G\,.\,h$ is liberated, and therefore Gh may be substituted for A in the preceding equation, which finally gives

$$h=\frac{10}{g}(v-5),$$

But g is approximately equal to 10, and therefore

$$h=v-5$$

may be accepted as being approximately correct. This equation shows that the height of fall through an airhole increases with the speed of the airship, and that it is independent of the weight of the airship (the latter because G does not figure in the equation for h). The author calculated in Table 1 the height of fall through an airhole due to the ship coming from air moving at 10 m (say 32 ft.) per sec. into still air, as functions of the speed of the airship.

COMPETITION FOR THE ROYAL PRIZE FOR THE BEST GERMAN AVIATION ENGINE (*Der Wettbewerb um den Kaiserpreis fur den besten deutschen Flugzeug-*

motor. *Deutsche Luftfahrer-Zeitschrift*, vol. 17, no. 3, p. 49. 6 pp., 14 figs. *de*). Description of the testing laboratories and methods to be used in this competition, as well as some of the engines that will take part.

Air Machinery

THE EQUIVALENT OPENING OF A VENTILATING SYSTEM AND THE CHARACTERISTIC CURVES OF A FAN (*Die gleichwertige Öffnung einer Luftanlage und die Kennlinien eines Ventilators*, Dr. -Ing. M. Kloss. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 52, p. 2095, December 28, 1912, 7 pp., 10 figs. *etA*). To compare two fans, the actual resistance of each of the respective ventilating systems is replaced by an artificial one, such as a restricted (throttling) opening. This can be done because, as known, for a given opening the static pressure h_1 varies with the square of the volume of air V, so that the ratio $\frac{V_1}{\sqrt{h_1}} = \frac{V_2}{\sqrt{h_2}}$ is constant for a given throttling opening. The author passes then to the consideration of the equivalent opening, and shows the derivation of the equation

TABLE 1 SPEED OF AIRSHIP AND HEIGHT OF SAG THROUGH AIRHOLE

v in km	v in miles per min.	v in m	v in ft. per sec.	h in m	h in ft.
50	31	14	46	9	29.5
75	47	21	69	16	52.5
100	62	28	92	23	75.5
125	78	35	115	30	98
150	93	42	138	37	122

$$A = \frac{V}{\mu} \sqrt{\frac{\gamma}{2gh}}$$

where μ is the coefficient of contraction; V volume of air in cbm; γ specific weight of air in kg/cbm; h total pressure head; g coefficient of acceleration due to gravity $= 9.81$ m/sec². For mine ventilation μ is accepted to be equal to 0.65, which makes $A = 0.395 \frac{V}{\sqrt{h}}$. The *equivalent opening is therefore such an opening in a thin plate as offers to the air the same resistance as the entire ventilating system in operation.*

The author proceeds, however, to show that the restricted opening and equivalent opening as calculated by the above formula with $\mu = 0.65$ do not coincide when the volume of air delivered exceeds a certain limit. The value of μ is apt to be greater than 0.65 both for large and even for small openings, and, in addition to that, as the author found from his tests, it is not constant. The conception of an equivalent opening loses therefore its original physical significance, and becomes a purely mathematical quantity, which has not even the justification of practical utility, since it unnecessarily cumbers the calculations, and, not being of constant value, may easily lead to false results.

Instead of the equivalent opening, the author proposes therefore to use another conception based on the law stated at the beginning of this abstract, viz., the pressure head required for a given resistance is proportional to the square of the volume of air. The resistance head of a ventilating system is:

$$h = \Sigma\ \zeta\ \frac{v^2\gamma}{2g}$$

where ζ denotes the head loss due to friction and v the velocity of air in m/sec., which may be further expressed by $v = \frac{V}{F}$ with F as sectional area of the air ducts at the point where the velocity v prevails. The volume of air V, equal for all cross-sections, can therefore be placed before the summation sign, and the above equation expressed in the form

$$h = V^2\ \frac{\gamma}{2g}\ \Sigma\left(\frac{\zeta}{F^2}\right) \text{ or } \frac{h}{V^2} = \frac{\gamma}{2g}\ \Sigma\left(\frac{\zeta}{F^2}\right) = \text{const} = R$$

and from this the next step is to use the resistance coefficient R, constant for a given ventilating system, as the basis for calculating purposes, without introducing such an auxiliary quantity as an equivalent opening.

Air delivery, pressure difference, power consumption and efficiency of a fan have been usually expressed as functions of the equivalent opening; if one attempts now to replace the equivalent opening by the resistance factor R as an independent variable, a difficulty arises in that in the limit case (closed fan) an infinite magnitude enters into the calculation since for $V = \infty$, the resistance factor $R = \frac{h}{V^2} = \infty$. It is therefore more advantageous to draw the characteristic curves of a fan by plotting, at constant speed of the fan n, the static pressure h, power consumption P and efficiency as functions of the volume of air V. It has been established by numerous tests that the air volume is proportional to speed in revolutions, while the pressure is proportional to the square of that speed. As regards the power consumption, tests made at the testing laboratory of the Siemens Brothers Dynamo Works, Ltd., in Stafford have shown that the power consumption of a centrifugal fan, the external resistance being constant, varies as the third power of the speed in revolutions. This does not include power losses through friction in bearings. The external resistance being constant, the efficiency of a centrifugal fan is constant and independent of the speed. There is therefore for each fan a certain definite external resistance $R_m = \frac{h_s}{V^2}$ at which it works at its best efficiency, and that at any speed.

To determine the behavior of a fan under any conditions whatever, at least two characteristic curves have to be plotted, preferably those of pressure and power consumption (or efficiency) as functions of the air volume. Since the relation between air volume, pressure, and power consumption on one hand and speed on the other have been shown to be known when the external resistance is constant, it is further advisable to plot the curves with constant speed, but varying external resistance; when the speed is not constant, the data obtained may be always easily reduced to constant speed. In fact it is a good plan to take for each resistance two or three points at various speeds, reduce the data by calculation to the same speed and take the average of those values. This will help to obtain particularly smooth curves.

The author gives data of tests and characteristic curves for the Keith-Black-man, Sirocco and Siemens fans, which cannot be reproduced here owing to lack of space.

Test of a Reciprocating Compressor Plant at the Dahlbusch Mine, Shaft II/V. (*Untersuchung einer Kolbenkompressoranlage auf Zeche Dahlbusch Schacht II/V. Glückauf*, vol. 49, no. 5, p. 170, February 1, 1913, 4 pp., 10 figs. *de*). Communication of the Society for Boiler Inspection of the Mines of the Dortmund Mining District at Essen, Germany. The tests were made in November 1912. The compressor is of the twin-tandem type, with the high-pressure steam and air cylinders in series on the right-hand side, and the low-pressure cylinders similarly arranged on the left side, the steam pressure being directly transmitted from the steam to the air pistons by means of piston rods. The steam and compressor cylinders are centrally interconnected by heavy intermediate pieces, both connecting pieces and steam cylinders being provided with special feet resting on a foundation with a machined surface which permits the free motion of the engine backwards when expanding from heat. The valve gear of both cylinders is as shown in Fig. 1 A. The beginning and end of the suction, and cutting-off of the pressure period are regulated by means of slide valves, while the beginning of the overflow of compressed air is determined, dependent on the degree of compression in the delivery chamber, by means of large spring-loaded non-return valves situated on the front end of the slide valves and moving together with them. The slide valves are driven by eccentrics from the crankshaft. As the slide valve at the end of the compression period at the dead center cuts off the connection to the cylinder, the non-return valve joined to it has all the suction stroke duration for its closing, and, moreover, its closing is due not to the large difference in pressure on both sides of the valve, but to the comparatively slight action of the spring, with a perfect equality of pressure on both sides of the valve. Notwithstanding its long stroke it can therefore in the time allowed reach its seat gradually and, what is of material importance, without excess of air pressure on one side. The valve action, even at high speeds of rotation of the engine is therefore very smooth and noiseless. The installation of the non-return valve in connection with the slide valve has also the further advantage that the slide valve is not loaded on one side by the air pressure, and the valve gear does not do any compression work. Between the low and the high-pressure cylinders is a recooler consisting of a wrought-iron boiler with a system of brass cooling pipes and cast-iron covers.

The steam engine is built so as to use superheated steam, and has the governing so arranged that a practically constant pressure in the air piping may be maintained: for this purpose the speed of the engine may vary from 25 to 100 r.p.m. (this is done by means of a compressed air governor device not described in the article).

The mechanical efficiency of the plant is said to be at least 88 per cent, the volumetric efficiency, according to the diagram, at least 92 per cent, with a suction output of 9.2 cbm (325 cu. ft.) per i.h.p-hr.; the compressor was guaranteed to compress from atmospheric to 7 atmospheres gage 10,000 cbm (35,000 cu. ft.) at 70 r.p.m., and 14,000 cbm (49,000 cu. ft.) at 100 r.p.m., with a permissible output variation of 5 per cent.

Fig. 1 B is the diagram for the high-pressure, and C for the low-pressure steam cylinders; D and E are for the high and low-pressure air cylinders respectively, all drawn to a scale of 4 mm = 1 kg (1 in. = 13.97 lb.).

The article contains full test data for both the engine and compressor; abbreviated test data for the latter are given in Table 2.

Investigation of Compressed Air Apparatus (*Untersuchungen an Pressluftwerkzeugen*, R. Harm, *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 5, p. 179, February 1, 1913. 4 1/2 pp., 13 figs. *eA*). Moeller, Baril and others have attempted to determine by graphical and mathematical means the processes occurring in compressed air machinery, but, owing to the complicated nature of the processes investigated, these attempts cannot be considered to have given fully reliable results. Professor Schlesinger, director of the Laboratory for testing machine tools at the Berlin Technical High School, with the collaboration of the author of the present article, has therefore evolved experimentally a system of apparatus and processes for investigating compressed air tools. The description of this system forms the subject of the first part of the article by Dr. Harm. To indicate this kind of machinery by taking pressure-path diagrams is impossible, first because the piston of the striking tool cannot be used to drive the indicator drum, and second, because the speed of operation, varying from 800 to several thousands blows per minute is too high,

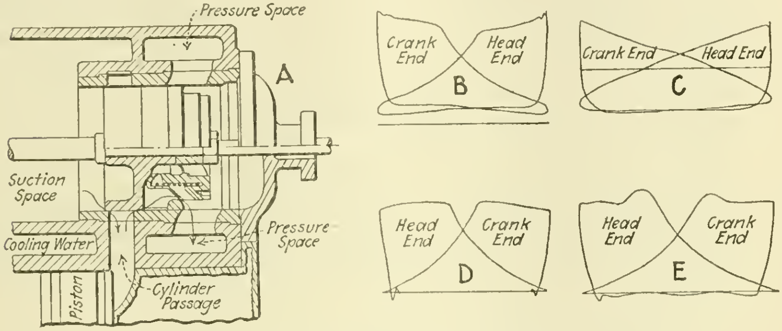

Fig. 1 Dahlbusch Mine Compressor Tests

TABLE 2 DATA OF COMPRESSOR TEST AT THE DAHLBUSCH MINE

	No. 1.	No. 2.
Speed of engine, r.p.m	69.7	96.0
Engine output, h.p	1075.6	1569.7
Average pressure of compressed air, atm. gage	7.03	7.1
Temperature of the air sucked in, deg. cent./fahr	11.6/52.8	12.5/54.5
Temperature of air behind the low-pressure cylinder, deg. cent./fahr	110.2/230.3	110.5/230.9
Temperature of air in cooler, deg. cent./fahr	17.4/63.3	18/64.4
Temperature of air behind the high-pressure cylinder, deg. cent./fahr	110.2/230.3	110.5/230.9
Output of compressor, i.h.p	962.4	1399.3
Mechanical efficiency of the plant, %	89.5	89.1
Volumetric efficiency of the compressor, %	91.8	91.1
Air sucked-in per hr., cbm/cu.ft	9363.8/ 330,549	13345.0/ 471,078
Air sucked-in per i.h.p-hr	9.08/320	8.50/300

to make this method practicable. Only pressure-time diagrams can be taken, by means of an optical indicator, but they alone are not sufficient to permit the construction of the pressure-path diagram, since there is no way, as in the case of engines having a crank-drive, of automatically regulating the action of the piston. A second indicator process therefore becomes necessary, viz., one that would give a piston-path-time diagram, and this process the author illustrates and describes in full.

The test data were computed as follows. From the reading of the air meter or calibrating tank and stop-watch readings was found the actual amount of air consumed in a given time, and this was reduced to standard conditions (0 deg. cent. and 760 mm mercury) or V_{red}, by means of a calibrating table and the usual formula. From the speed in revolutions of an indicator disc is determined the peripheral velocity u of the disc, and by its means the time t_x for any point on the diagram. Of particular interest is the total time t of a piston period of operation, and the times t_r and t_h of the return and forward strokes, determined graphically from Fig. 2*D* (abscissae l, l_r and l_h). The number of blows $z=\frac{60}{t}$ is likewise determined thereby. The ordinates of the diagram represent, in natural size, the piston paths, the respective velocities being $v_x=u \tan v$ The following velocities have been selected, with their equations, as particularly characteristic for the action of the piston:

Velocity of blow $v_\alpha=u \tan \alpha$
Velocity of recoil $v_\beta=u \tan \beta$
Maximum velocity of return stroke $v_\gamma=u \tan \gamma$
Average velocity of return stroke $v_r=u \tan \delta$
Average velocity of forward stroke $v_h=u \tan \epsilon$

This shows that, to obtain the respective actual piston velocities, it is only required to multiply the trigonometric tangents of the angles by the peripheral speeds u. The ratios of these velocities to each other are also of considerable interest. Thus

$$\frac{v_\beta}{v_\alpha}=\frac{\tan \beta}{\tan \alpha}=\text{recoil coefficient } \rho$$

$$\frac{v_\gamma}{v_\beta}=\frac{\tan \gamma}{\tan \beta} \text{ and } \frac{v_\gamma}{v_\alpha}=\frac{\tan \gamma}{\tan \alpha}$$

For the capacity of this class of tools the following magnitudes are of importance: the energy of the blow $E=\frac{m}{2}v_\alpha^2$mkg (m is the mass of the part having a reciprocating motion); energy of recoil $E_r=\frac{m}{2}v^2_\beta$ and the energy which the piston gives up $E_a=E\ (1-\rho^2)$; output of blow $N_1=\frac{E\,.\,z}{4500}$ in h.p., and corresponding to it $N_a=N_1\ (1-\rho^2)$. Since maximum ease of operation is usually required in compressed air tools, $\frac{N_1}{G_H}$ is also of importance: G_H is here the total weight of the tool.

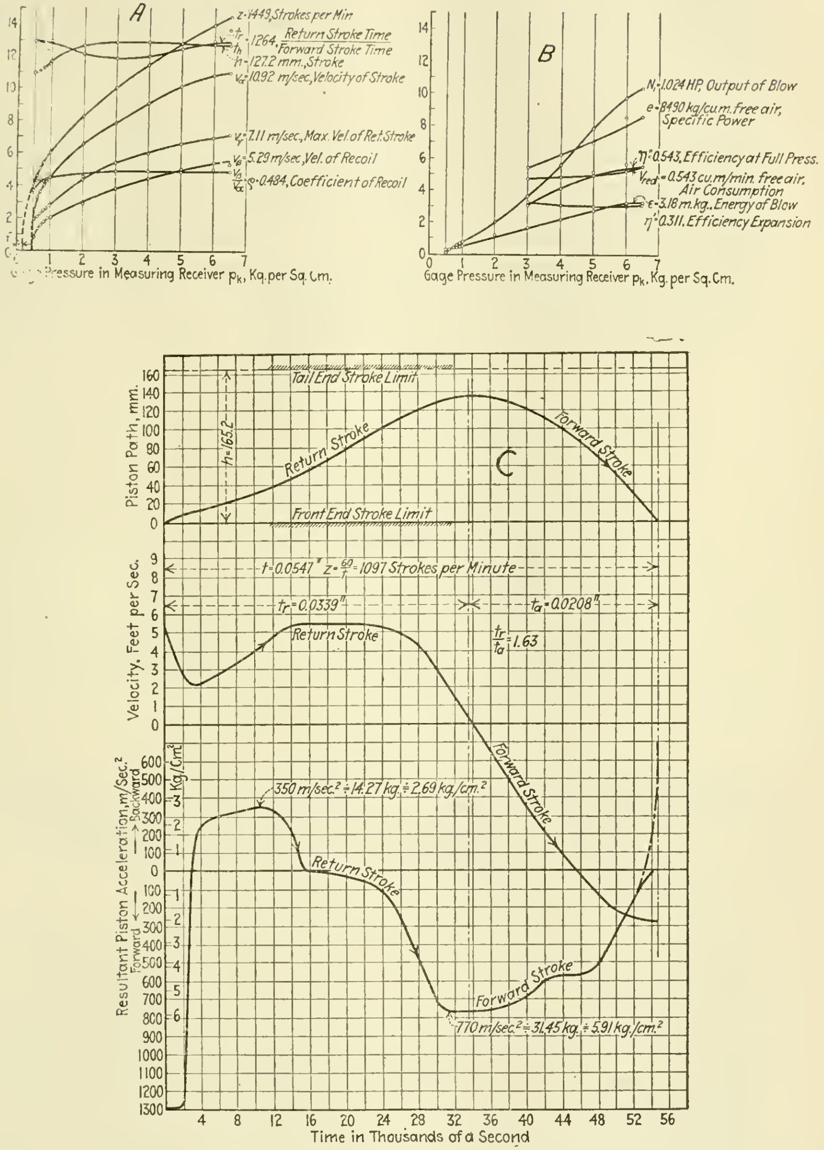

Fig 2 Compressed Air Machinery Tests

Economy of Operation. Data as to the air consumption have little value unless the work done by the hammer is also considered simultaneously. The specific output of a compressed air tool may be expressed by

$$e = \frac{E \, . \, z}{V_{\text{red}}}, \quad \text{or} \quad e_a = e\,(1 - \rho^2).$$

With these data for the utilization of compressed air, representing experimental values obtained by actual measurements, are to be compared theoretical values for the output, equally reduced to normal conditions and pressure p_2 kg/qcm. But with respect to this theoretical output the following distinction must be made: (*a*) the full theoretical output e' at perfect adiabatic expansion, and (*b*) the theoretical output e'' at full pressure, without the utilization of the expansion. The consideration of e'' is important because in many cases in practice no attempt is made to utilize the expansion, either so as to avoid the possibility of cooling the hammer down to the freezing point, or in order to obtain, for the same weight, as high an efficiency of blow as possible. In such cases e'' represents the ideal value. The values $\eta' = \frac{e}{e'}$ and $\eta'' = \frac{e}{e''}$ also represent important magnitudes in the estimation of a compressed air hammer.

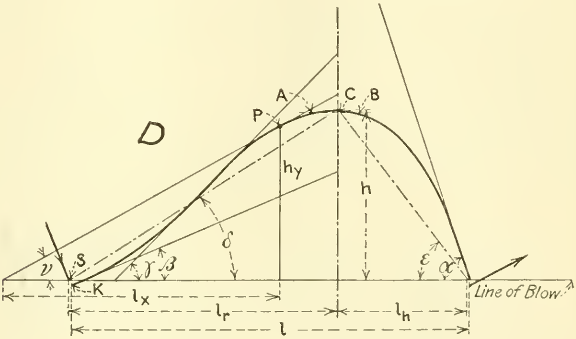

Fig 2 Compressed Air Hammer Tests

Figs. 2A and B give data obtained from the tests of a compressed air hammer at various air pressures. The velocities and numbers of blows per unit time show very well the parabolic curves which the mathematical and mechanical reasoning lead one to expect.

A more thorough investigation of the processes inside the hammer by means of time-path diagrams may be made mathematically and graphically by methods similar to those shown in Fig. 2C where, by differentiation, are derived the velocity-time and acceleration-time diagrams. From these and the previously obtained path-time diagram may be finally derived the velocity path and acceleration path diagrams. This investigation on the whole has shown that the process used is an unusually reliable and interesting method of gaining an insight into the processes occurring in compressed air tools.

Firing

New Patented Flue Dust Catcher (*Neuer patentierter Flugaschen- und Staubfänger, Braunkohle*, vol. 11, no. 45, p. 726, February 7, 1913, 1 p., 2 figs. *d*). The disadvantage of the usual flue dust catchers is the loss in draft resulting from their use. The flue dust catcher of the Zeitzer Dampfkesselfabrik und Apparatenbauanstalt G. Schumann, of Zeitz, Germany, is claimed to reduce such losses to a minimum. The gases are led from the boiler to an expansion chamber (Fig. 3) of such proportions as to permit the solid particles to settle by gravity, owing to the decrease of the velocity of the gases carrying them. The chamber is provided with a number of settling cells arranged one behind the other as shown in the drawing, with their height decreasing in the direction of the flow of the gases, and having the rear wall, with its several grooves for receiving the settling dust, sloping in the direction of the flow of gases. By such an arrangement of the cells and lower wall the total section between the cells, or in the settling zone proper, is made equal to the section of the chamber itself, and the gases flow over the settling cells in small streams, at a low velocity and at an elevation above the cells proportional to their distance from one another. The solid particles have therefore to travel only a very short distance, and, with proper proportions of the device, each solid particle, no matter in what zone of the gases it may be, must separate out. As soon as it falls into a settling groove or cell, it is carried off by special piping to the ash collector, and cannot therefore be carried out again by the flowing gases. The moderate dimensions of the device permit its installation nearly everywhere.

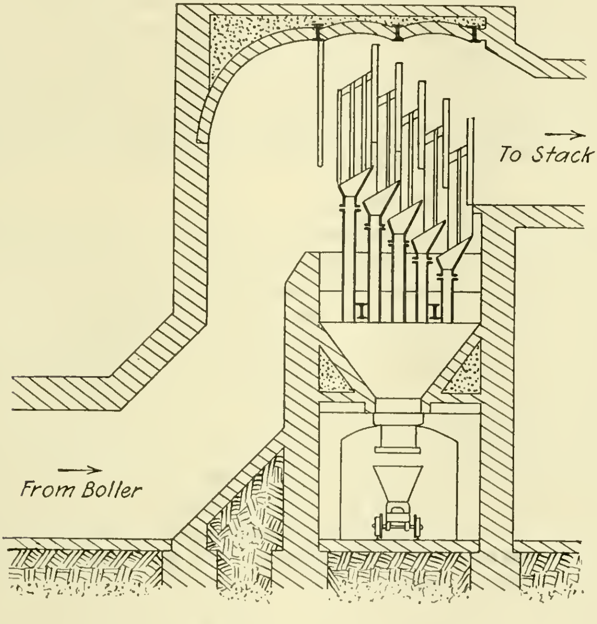

Fig. 3 German Type Flue Dust Catcher

Hydraulics

The Construction of Francis Blades in accordance with the Lorenz Turbine Theory and their Properties (*Die Konstruktion der Francis-Schaufel nach der Lorenzschen Turbinentheorie und ihre Eigenschaften*, Bauersfeld. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 51, p. 2045, December 21, 1912. 6 pp., 7 figs. *mt*). Lorenz has made possible the mathematical investigation of the theory of the turbine by replacing the accelerations in the blade surfaces by a constant field of force, so that the flow could be considered as if it were occurring with perfect uniformity about the axis of the turbine. This assumption is in full agreement with an assumption of an infinite number of turbine blades. The author starts from this theory of Lorenz and derives a graphical method for the design of turbine blades, and establishes the conditions which have to be observed in the selection of the inlet edge and length of blade. He indicates also the variations occurring in the flow through the rotor when the amount of water flowing and the speed of rotation vary. Thus he shows that in the Jonval turbine the angle of entrance along the entire inlet edge must be in excess of 90 deg. in order that the main flow be free from eddies.

Internal Combustion Engines

Horizontal Diesel Engines of the German Automobile Construction Company of Berlin (*Liegende Disselmäschinen der deutschen Automobil-Construktionsgesellschaft, Die Gasmotorentechnik*, vol. 12, no. 11, p. 169, February 1913. 4 pp., 4 figs. *d*). Only vertical Diesel engines have been built as long as the Diesel patents were alive, because the manufacturers had enough orders and did not care to go to the expense and risk of developing a new type. Since then the horizontal engine has been made as reliable and smokeless as the vertical. In the engines of the German Automobile Construction Company the flywheel is on the camshaft side while the compressor is located horizontally on the other side of the engine frame. The advantage of such an arrangement lies in that a second cylinder may be built in on the far side from the flywheel, in which case all the valves of the second cylinder are taken care of by the valve gear of the first cylinder, with no additional camshaft, while the compressor is shifted to the off-side of the second cylinder. In addition it permits of the construction, without extra patterns, of twin two and four-cylinder engines, using both sides of the flywheels; in this case both camshafts are easily accessible. With three sets of patterns only seven types are built:

One Cylinder, H.p.	Two Cylinders, H.p.	Four Cylinders, H.p.
20	. . .	. . .
50	100	200
100	200	400

The machine with a larger number of cylinders is taken in preference to one of equal power with a lesser number of cylinders when a particularly high uniformity of running is of importance. To decrease the noise of air suction, the air is taken from the basement by a long pipe which has the additional advantage of always supplying the engine with fresh air free from oil vapors. To make the piston pressure on the guide face of the cylinder as low as in vertical engines of the same dimensions, the ratio of connecting rod length to crank radius was increased. The article describes in some detail the valve gear and lubrication arrangement. The engine is started by compressed air. Cp. also the Standardization System of J. E. Christoph Co., *The Journal*, January 1912, p. 132.

THE FORMATION OF OIL DEPOSITS IN THE CYLINDERS AND BEARINGS OF STEAM AND GAS ENGINES (*Über Bildung von Ölrückständen in Zylindern und Lagern von Dampf- und Kraftmaschinen*, H. Schlüter. *Chemiker-Zeitung*, vol. 37, no. 22, p. 221, February 20, 1913, 2 pp. *p*). The author discusses a number of cases where *deposits* formed *in the cylinders and bearings* of various engines, and by comparing the analyses of the deposits and oils used, shows that in most of the cases where the trouble occurred the amount of mineral matter in the deposits was out of proportion to that in the oil, which proved that the fault was due not to the oil, but either, as in the case of steam engines, to carelessness in operation, or, with blast furnace gas engines, with poorly cleaned gas. Only under exceptionally unfavorable conditions of operation can lubricating oils free from solid matter form deposits through simple oxidation in the cylinders of steam and gas engines, as happens sometimes in compressor cylinders.

INCREASE OF OUTPUT OF INTERNAL-COMBUSTION ENGINES AND A NEW SIX-STROKE CYCLE ENGINE (*Die Steigerung der Leistung von Verbrennungsmotoren und ein neuer Sechstaktmotor*, E. Schimanek. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 4, p. 134, January 25, 1913. 8 pp., 18 figs. *dt*). The improvement of the output of internal-combustion engines may be sought along the following lines:

(*a*) Improvement of economic efficiency by better fuel utilization (the gases are subjected to a longer expansion, the volume at the end of expansion is equal to cylinder volume or that at the beginning of compression): has been proved theoretically and practically that, with increasing compression, beyond certain limits the advantages practically stop, and, e. g., in the case of constant-pressure engines, compression above 38 or 40 atmospheres does not improve the efficiency any more.

(*b*) Increase of the number of working strokes per unit of time. This can be done in two days: (1) by increasing the speed of the engine (speed above 200 to 300 r.p.m. does not improve the efficiency any more, while high speed always unfavorably affects the life of the engine); or by (2) the reduction of the number of strokes at which no work is done (double-acting and two-stroke cycle engines; a calculation is given to show how the efficiency of the two types compare with each other).

(*c*) Increase of the amount of air handled by the motor per fuel charge (by lowering the temperature of the air, reduction of the amount of products of combustion remaining in the working cylinder and filling up the space thus liberated by clean air, and by increasing the air pressure previous to compression).

The second of these methods is applied in the so-called scavenging engines, as well as to a certain extent in six-stroke cycle engines (for six-stroke cycle engines generally see Güldner, The Design and Construction of Internal Combustion Engines, New York, 1910).

In the case of a four-stroke cycle engine, the output may be increased by supplying to the working cylinder compressed air from a special receiver in which the compressed air is replaced by a pump. The pump must then supply the entire air handled, and the dimensions of the working and pump cylinders depend on the desired pressure or improvement in the output; the pump, which works on the two-stroke cycle, must have a cylinder either equal to the working cylinder, if it is single acting, or of half its volume, if it is double acting, so that the ratio for the same output between the combined cylinder and pump volume for the improved and ordinary types of four-stroke cycle engines is for 2 atmospheres pressure in the first case $a = 1$, and in the second $a = 0.75$; for 1.5 atmospheres pressure a becomes respectively 1.166 and 0.913. Another way is to take part of the air from outside, and only supplement from the receiver. In this case the working process is as follows: the working cylinder at the first stroke draws in outside air, and at the end of the suction stroke, after the suction opening has been closed, the working cylinder is set into communication with the receiver, so that the air compressed by the pump flows into it and raises the pressure; this is followed by the usual compression, expansion and exhaust. If now the working cylinder takes in as much air from outside as from the receiver, then previous to compression (isothermic compression in the pump and instantaneous free-of-losses passage of air to the working cylinder at the dead center being assumed) the pressure in the working cylinder is 2 atmospheres and the output twice as large as in the ordinary four-stroke cycle engine. Since with a single-acting pump the total volume of the working and pump cylinders is 1 + 0. 5, the ratio a becomes $\frac{1.5}{2} = 0.75$; with a double-acting pump it is $a = \frac{1 + 0.25}{2} = 0.62$.

The thermal efficiency of such an engine is somewhat lower than that of an ordinary four-cycle engine, and the more so the smaller the size of the receiver because in the overflow of air, apart from acceleration and throttling losses, there are losses due to the flow of air from the receiver where it is at a high pressure, to the cylinder where a lower pressure prevails, But the efficiency of a four-stroke cycle may also be improved without introducing a separate air pump, but by applying a special process invented by the author. The essential part of this new process consists in making several suction strokes before each compression or expansion stroke. The air taken in before the last suction stroke is stored in a receiver up to the last suction stroke when it is conveyed to the working cylinder and there forms part of the explosive charge. This cycle may be of six or more strokes. In the six-stroke cycle shown in Fig. 4 A the sequence is as follows: stroke 1: suction of outside air, *A—B;* stroke 2: compressed air driven into the receiver, *B—C;* stroke 3: suction of outside air, *C—D;* between the third and fourth strokes the air flows over from the receiver into the working cylinder, where the pressure rises to about 2 atmospheres, *D—E;* stroke 4: compression of the charge, *E—F;* stroke 5: combustion and expansion, *F—G;* stroke 6: exhaust, *G—H*. With this process in six strokes twice as much air is handled as in a four-cycle engine in four strokes, and, for the same number of revolutions, the output is 1.33 times as great as in the latter type; not counting losses connected with the overflow of air, the same cylinder volume in the six-stroke cycle gives about 33 per cent more output than in the four-stroke.

In actual operation, however, this is not quite so. The conditions are the same as in a four-stroke cycle engine only during the first suction stroke, while previous to the second and following strokes the pressure in the compression space of the cylinder is that of the receiver, and the volumetric efficiency is therefore affected by the expansion of the air from the receiver pressure to the atmospheric. At the second and following (in engines of cycles higher than the six-stroke) suction strokes the volumetric efficiency can be good only when the compression space is not too large, and the application of this principle is therefore limited to engines with a high compression pressure, that is, to constant-pressure engines.

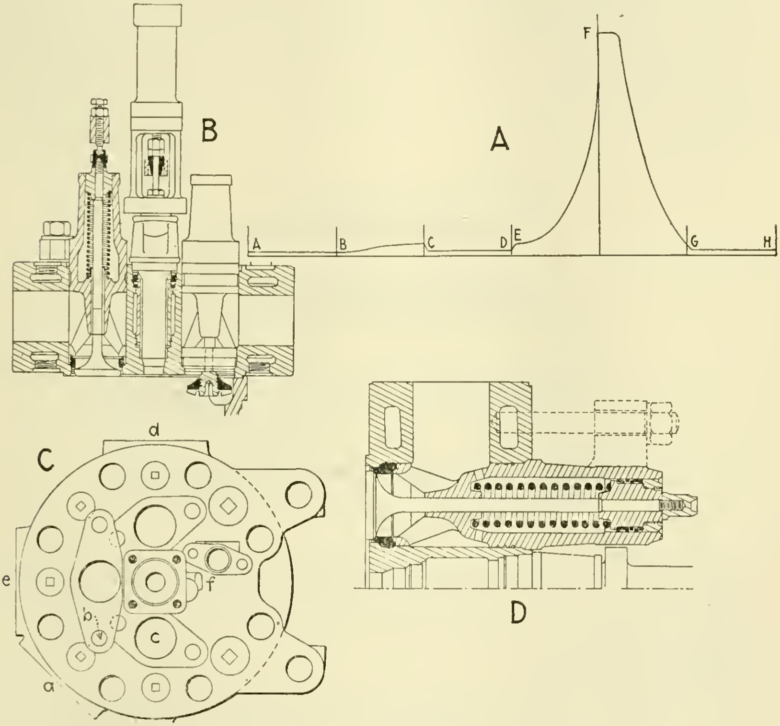

Fig. 4 Schimanek Six-Stroke Cycle Engine

As regards the ignition of the fuel only small amounts of heat can escape through the receiver walls, owing to the comparatively low temperature of the stored-up air and its low conductivity; the fall in temperature due to this loss of heat is further compensated for by the rise of temperature due to throttling. The final temperature does not therefore substantially differ from that of four-stroke cycle engines using similar pressures, and the final pressure need not exceed 60 atmospheres, as in the four-stroke cycle engine. Actually, however, only about 50 atmospheres are used, which makes a larger compression space necessary, and somewhat reduces the thermal efficiency of the engine. As regards losses of heat to the cooling water, in the four-stroke cycle the cooling does no useful work during the suction and exhaust strokes, and affects the compression stroke but little. It affects harmfully the utilization of the fuel heat content only during the combustion and expansion strokes. In the six-stroke cycle there are five strokes during which the cooling water does no harm, and therefore for the same number of revolutions per minute the loss to the cooling water is less in the case of the six-stroke cycle engine than in the four-stroke cycle. The Schimanek engine working on the six-stroke cycle is shown in Fig. 4 B and C, and the overflow valve permitting the air to flow from the receiver into the cylinder between the third and fourth stroke, as explained above, in Fig. 4 D. The article contains full data of tests which cannot be given here owing to lack of space. The useful output of the new engine (about 40 h.p.) was found to be 20 to 25 per cent in excess of that of a four-stroke cycle engine of similar dimensions. There are no data as to the first cost of the new type as compared with those now in existence.

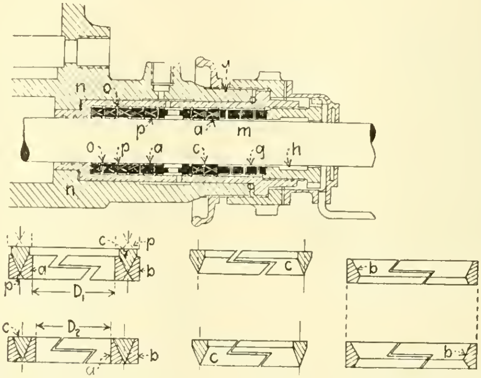

Fig. 5 German Self-packing Stuffing Box

Machine Elements

Self-Packing Metal Stuffing Box (*Selbsdichtende Metallstopfbuchse*, H. Hirschlaff. *Zeits. für Sauerstoff- und Stickstoff-Industrie*, vol. 5, no. 4, p. 67, February 20, 1913, 2½ pp., 5 figs. *d*). Description of a new stuffing-box patented in Germany (D.R.P. no. 256,134). It is said to give an excellent packing for compressors, pumps, gas engines, etc., and to be self-adjustable within wide limits. The packing has three one-piece, slit and elastic rings *a*, *b* and *c* (Fig. 5). By tightening the gland *h* the central wedge-shaped rings *c* are displaced axially, and cause the rings *a* and *b* to press against the piston rod *m* or the stuffing box neck *n*. As a result, the internal rings *a* are radially contracted twice as much as the middle wedge-shaped rings, while the outer rings *b* undergo no change as far as the diameter is concerned, and are only successively displaced radially towards the gland. This in its turn results in a wide radial adjustability of the packing and, in connection with a good system of lubrication, leads formula for density. The tables published by the Navy Bureau of Construction and Repair show the weight of air for different temperatures, barometer readings and humidity up to 100 deg. and are a time saver within their range. Formula [15] applies to any gas by using the density of the gas measured. (See also Pars. 44 and 45.)

As to measuring the velocity of air flow in a pipe with the pitot tube at the center, the correction for average velocity should usually be determined by trial and especially if the pipe is short or if flow is in any way irregular. If gates are used on the measuring pipe it is necessary or the error may be considerable.

As to the velocities of air affecting the correctness of the pitot tube readings my evidence is that these readings are correct at least to the limits stated and up to the speeds experimented with. That is, both static and impact orifices if they are as in Fig. 1 give true static and true impact pressures. The method of calibration is simple and direct especially for static orifice.

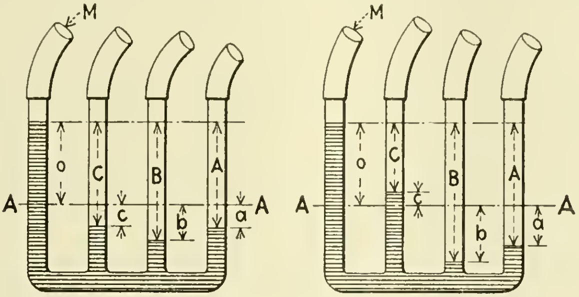

Fig. 15 Fig. 16

Equal Areas and Sections in Pitot Tubes for Use with Inclining Manometer

Possibly Mr. de Laval's experience has been with some of the forms having a faulty static orifice with which calibration was required to determine a constant in the relation $v = \sqrt{2gh}$. The form shown in Fig. 1 is simple and easy to make, the tip consisting of a $\frac{1}{8}$-in. tube inside a $\frac{1}{4}$-in. diameter tube with walls about $^{1}/_{32}$ in. thick. Both static and impact are correct if made as shown. Accurate pressure measuring instruments are available and must be used and the ordinary precautions taken against leaks, etc., as noted through the paper and in Pars. 18 to 25.

THE VAUCLAIN DRILL

By A. C. Vauclain and H. V. Wille, Published in The Journal for October 1912

ABSTRACT OF PAPER

In the usual type of drill there are four distinct cutting edges. The actual cutting, however, is done mainly by the two edges extending from the outer circumference to points near the center. At the central portion of the drill are the two shorter cutting edges constituting the "chisel point" which do not cut freely and introduce stresses tending to split the drill.

The paper describes a new type of twist drill which has two radial cutting edges and in which the usual chisel point of such drills is eliminated.

In this drill the stresses due to the chisel point are absent and the arrangement of the cutting edges is such that a greater thickness of metal is secured at the center of the drill, adapting it to heavy feeds by which means the most economical results are secured in drilling.

Tables are given showing the results of comparative tests with the Vauclain and regular types of drills, indicating a saving with the former of over half the horsepower expended with the latter type.

DISCUSSION

J. Sellers Bancroft asked if any efforts have been made to ascertain the accuracy of diameter of holes drilled with the Vauclain drill. He thought it would be difficult to get the point of the drill exactly central, and in the production of holes of accurate size it is necessary for the reamer, which follows the drill, to have a definite amount to take off throughout. This amount should be neither more nor less.

H. P. Fairfield. The report of the horsepower expended as given in Table 3 shows a remarkable difference between the regular and the Vauclain drills. It would seem as if such differ-

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

ences in results could not be due to the design of the drills themselves, but must be the result of the method of testing. It would be interesting, therefore, to know how these tests were made and the apparatus used to measure the efficiency of the several drills. The reader could then analyze the tests and judge for himself as to their reliability and exactness. In much of the ordinary drill testing, the weaknesses and friction losses of the drilling machines are registered and charged to the drills being tested, which is obviously unfair. Several years ago at the Worcester Polytechnic Institute a drill testing dynamometer was developed which obviates such errors, registering only what is taking place at the drill point and entirely eliminating the drilling machine from the readings taken. If anyone compares his dynamometer results with the power input of this machine he will be shown conclusively that tests based upon the differences in power input are extremely unreliable. It is for this reason that the writer believes the method of conducting the tests should have been included. In a series of dynamometer tests upon a regular and a Vauclain drill made since reading the paper, the results showed no material differences in horsepower expended, and the writer cannot see why there should be such differences as shown in Table 3. As furnished him, the Vauclain drill is essentially a point thinned drill. Therefore the pressure at the point is reduced and the distortion in the machine lessened. However, if the regular drill is point thinned as is often done, the results in thrust are essentially the same.

The Vauclain drill appears to lend itself more readily to the point thinning principle than does the regular drill, and if extended use and tests should prove this to be so, it is obvious that an advance in drill construction has been made.

E. C. Peck. This paper points out a great many weaknesses of the well-known twist drill and has attempted to prove the superiority of a new type, but the author has described neither the apparatus nor the exact conditions under which the tests were made, in a way such that the student may judge to what particular detail the difference in results is traceable.

In Par. 1 he says the best definition of economical drilling is rapid drilling; this is not necessarily true. The writer has drilled cast iron 4 in. thick with a 1½-in. drill at the rate of 64 in. per min., probably the record at this date for rapid drilling, but it was not economical because it consumed too much power and the drill was too near breaking all the time. A better definition of economical drilling is "the greatest amount of drilling that can be done per $1, counting the cost of time, power, machinery and drills."

In Par. 8 he says "The speed remaining constant—the power consumed by the *machine* remains constant for all feeds." It would be interesting to know how he determined this, as the coarser the feed the heavier the pressure on the drill to make it penetrate, and this puts more pressure per square inch on thrust bearings and feed parts which in turn increases friction.

Referring to Fig. 1, the cutting edges *A* and *B* being ahead of the center presents an advantage that the author has not mentioned, viz., they make a shearing cut with a tendency to carry the curling chips away from the axis of the drill.

The author lays stress on the splitting of drills and demonstrates the reason for this failure, but the splitting of drills is not a serious matter and a split drill usually shows a defect in the material or improper grinding, a fact which any large user of drills can easily verify by careful observation. The writer is in a position to observe the performance of several thousand drills each month which are tested to destruction under severe conditions and not one in 10,000 fail by splitting. If the chisel point spoken of has an inclination to the cutting edges *A* and *B* as shown in Fig. 1, there will be enough clearance at the center and the chisel point will cut easily enough to avoid splitting.

A great defect in the author's proposed drill, as shown by the writer's experience, is its inability to penetrate hard material. This is apparently due to the extremely thin center not being able to withstand the heavy feed pressure necessary to penetrate hard material. A more serious defect is the actual pressure of the chip against the surface *O* in Fig. 7. It does not curl freely as in the drill shown in Fig. 1 because there is no room; it must slide against the shoulder *O* Fig. 7.

In the regular type drill the cutting edge is extended past the axis an amount which allows free curl to the chips. If the regular and proposed drill used in the author's tests were properly thinned to the same thickness, there should be less power consumed by the regular drill because it bends the chips better.

Tests with Vauclain and regular drills made from the same bar of steel and heat treated alike showed in every case that to withstand heavy feeds (0.100 in.) the temper of the Vauclain drill had to be lowered 20 to 30 points below the regular drills to keep the centers from breaking and they were then too soft for high speeds.

The tables do not show the "rapid drilling" which might be expected from the author's statements. The highest rate given is 15 in. per min. and double this amount can be done with regular drills. It would therefore seem that more extensive tests will be needed to make the superiority of the Vauclain drill apparent.

The Author. In reply to Mr. Bancroft's question, accurate grinding of any drill is essential to the production of holes of accurate size. There is no difficulty in obtaining correct grinding in the Vauclain drill. No drill should be hand ground, and proper grinding machinery has been designed and built for grinding the Vauclain drill correctly. It is interesting, however, to note in this connection that much of the grinding of the Vauclain drills during the development was done by hand until the time when proper grinding machinery was available.

Replying to Mr. Fairfield, the author wishes to state that the remarkable difference in horsepower expended was not due to the method of testing but to the comparison between high speeds and heavy feeds. In other words, with a given rapidity of drilling a high-speed drill is made to depend upon high speeds and moderate feeds. The Vauclain drill utilizes heavy feeds and moderate speeds, the speed being kept just high enough to maintain within the drill a sufficiently high temperature to operate most successfully.

The author is not aware of any Vauclain drills having been furnished the Worcester Polytechnic Institute for the purpose of tests, and is of the opinion that perhaps such tests may have been made without a proper understanding of the intent of the drill design.

In reply to Mr. Peck, the apparatus and conditions under which the tests of the Vauclain drill were made were as follows:

The drilling machine used was a 60-in. radial drill press, one of a number built by Wm. Sellers & Co., Inc., of Philadelphia, and driven by a 20-h.p. variable speed direct-current motor. Current was supplied by an independent generator so that the machine was entirely segregated from shop lines, the object being to maintain as constant a voltage as possible. A Westinghouse recording wattmeter, also an ammeter and volt meter for direct readings were located about 75 ft. from the machine so that readings could be taken without encountering the dangers of flying parts of broken drills. In this same location there was installed a cut-out switch so that the machine could be stopped at any time without approaching it. A steel guard was placed about the drill spindle as a further protection against flying pieces of broken drills.

The material drilled was tough, hammered steel of approximately 0.45 carbon. Heavy slabs of this material were used so that holes would have to be drilled through a considerable depth in all cases.

The author in stating that the best definition of economical drilling is rapid drilling believes he is correct and that Mr. Peck has misunderstood the statement. The most costly element in drilling is that of time; and, by the saving of time, assuming a rational design of drill and of horsepower consumption, the amount of drilling that can be done per unit of cost will increase as the time consumed decreases.

In Par. 8, referring to the statement, "the speed remaining constant, the power consumed by the machine remains constant for all feeds," the author should perhaps have explained this matter more in detail. It is true, as Mr. Peck has stated, that the coarser the feed the heavier the pressure on the drill to make the cut, and this puts more pressure on the thrust bearings and feed parts, which in turn increases friction. Attention is called to the fact, however, that the friction due to end thrust of the drill is so small as compared with the total power consumed by the friction of the machine that it may be considered negligible so far as power consumption is concerned. That the power consumption varies directly as the speed is but a mechanical law which may be verified at any time and by anyone by electrical readings. To elaborate this further, assume that with a certain size drill and a given rate of feed and speed there is a gross consumption of 6 h.p., and that half of this power is consumed by the machine, leaving a net cutting horsepower consumed of 3. Next assume an approximate doubling of the rapidity of drilling. If this is obtained by doubling the speed, there will be a gross consumption of approximately 12 h.p. If, however, the rapidity of drilling is approximately doubled by increasing the feed and permitting the speed to remain unchanged, the gross consumption will be approximately somewhat less than 9 h.p. In a twist drill of the ordinary design, the difficulty of penetration and consequently the end thrust of the drill is aggravated by the chisel point. In the Vauclain drill, there being no chisel point, the end thrust upon the drill is very much less, consequently heavier feeds can be used in the Vauclain drill with less distress to the feed mechanism than would occur with the use of the ordinary type of twist drill.

The author cannot agree with Mr. Peck's statement that the splitting of drills is not a serious matter, and that the drill usually shows a defect in the drill material or improper grinding. The author has had a very large and intimate acquaintance with drills of all kinds. The central weakness of a milled drill is well known to all drill users. In the break-down tests made for the purpose of comparing the Vauclain drill with the ordinary design of drill, the ordinary designs of drill almost invariably split longitudinally, while the Vauclain drills, standing up under very much heavier duty as shown by the test data in the paper, fractured only when the torsional capacity of the section had been reached. Some of the drill manufacturers today, appreciating the seriousness of the central longitudinal weakness of the ordinary drill, have thickened their drills in the center, but this has increased the chisel point, consequently the difficulty of penetration. In the Vauclain drill there is no chisel point, consequently it may be made sufficiently thick in the center to enable the full torsional value of the drill section to be realized.

The author must disagree with Mr. Peck's statement in reference to the inability of the drill to penetrate hard metal. The Vauclain drill is especially adapted to the penetration of hard metal. It has no "extremely thin center." The so-called point on the Vauclain drill is merely the absence of a chisel point and is the strongest and most lasting and perfect part of the drill. It will not burn and it will not break under duties which would destroy the drill in every other respect.

With regard to the chip not curling, this is also incorrect. Since the cutting edges pass through the axis of motion, the chip at its inner edge has a length of zero while the maximum length of the chip is at the outer edge, consequently the outer edge of the chip is in rapid upward motion while the inner edge is approximately at rest. These circumstances, combined with the flute of the drill, give the chip the proper curl. No difficulty has been experienced with the Vauclain drill in this respect.

As to the temper of the drills having to be lower than that of the regular drills, this is not at all necessary, as stated by Mr. Peck, to prevent the centers from breaking. The author has stated that the Vauclain drill is a heavy-feed drill and has pointed out and substantiated the fact that high-speed drilling is less economical than heavy-feed drilling, also that high-speed drilling is the result not of desire or advisability, but rather of inability to obtain. in the ordinary type of drill, any great amount of physical strength. In the Vauclain drill a tough rather than a hard drill is required, and it is intended that these drills shall be drawn at a lower temperature than the high-speed drill of ordinary type.

With reference to the drilling of 15 in. per minute, it is to be understood that this was done in a piece of 0.45 carbon hammered steel, approximately 4 in. thick and that the drill was permitted to emerge from the bottom of the work under full feed without the slightest injury to the drill. In the author's opinion, the drilling of 64 in. per minute with 1½ in. drill in cast iron is not to be compared in severity with the test just referred to. The greatest evil of end thrust on an ordinary drill is that under heavy duty it is apt to break when emerging from the work. With the Vauclain drill feeds of ⅛ in. per revolution have been successfully carried with 1 9/64-in. drill at high speeds.

TESTS OF A 1000-H.P. 24-TUBES HIGH B. & W. BOILER

By B. N. Bump, Published in The Journal for October 1912

ABSTRACT OF PAPER

The tests described in this paper were made on an inclined header Babcock and Wilcox boiler, with superheater and mechanical stoker. The experimental unit was installed for the purpose of determining the maximum heat efficiency and fuel economy, and the variation of such efficiency with changes in the boiler rating, also to gather data useful in the design of a unit for a large installation. The peculiar feature of the boiler is the unusual height; the sections being 24 tubes high.

A Foster superheater was placed between the top row of tubes and the boiler drums, and the gases entered the superheater after passing over 24 tubes. The superheat was found to go up with the boiler rating, increasing from 30 deg. to about 75 deg. fahr. for a change in rating from 55 to 120 per cent.

The fuel was burned on a six retort Taylor stoker having a grate area, exclusive of dump grate, of 62.5 sq. ft. One of the results of increasing the height of a boiler is a large ratio of boiler heating surface to grate area, which in this case was 160 to 1. Such a large ratio limits the capacity of the boiler, making it impossible to run at high boiler ratings.

The best combined efficiency, 81.3 per cent, was obtained at about 56 per cent of rating. The efficiency decreases slowly with an increase in the boiler rating. The low rating tests show exit gas temperatures but little above the temperature of the saturated steam in the boiler. The radiation losses are low considering the exposed condition and the low atmospheric temperatures surrounding the unit.

DISCUSSION

W. D. Ennis. The results of these tests do not apparently harmonize with principles usually accepted. It is customary to think of a 3 or 3½ lb. rate of evaporation as that of maximum efficiency. At rates below this, the efficiency is reduced by the increased proportion of radiation loss, and by the lower furnace

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

efficiency, resulting from the low rate of combustion and necessarily excessive air supply. At evaporation rates higher than 3 or 3½ lb., efficiency is gradually reduced because of increased loss to the stack, as indicated by rising flue gas temperatures.

In this boiler, the efficiency steadily decreased as the rating increased, and the best efficiency was reached at an evaporation rate below 2 lb. When efficiencies are said to decrease at low rates the usual proportions of design are assumed: say with soft coal, a heating surface to grate surface ratio around 50. A 3 lb. evaporation rate means with this ratio, a rate of combustion of about 15 lb. per sq. ft. of grate per hour. No rate of combustion as low as this was reached in the present tests. In this boiler, with its unusual ratio of heating to grate surface, low rates of evaporation were not accompanied by low rates of combustion. At no time was the furnace efficiency notably lowered from the good average maintained.

It may seem that this scarcely explains the rate at which the efficiency apparently decreases with increased evaporation. As large a heating surface as was provided should have more completely absorbed the furnace heat. If Fig. 1-a is a scale drawing, a slightly better distribution of gas velocities would have been possible. It is quite easy, however, to over-emphasize the rate of decrease of efficiency, particularly as the *rating-combined efficiency* and *combined efficiency-gas temperature* curves of Fig. 2 are both represented to a distorted scale. The base line is that of 70 per cent efficiency, not of zero efficiency. The man on the street would say that the efficiency was about constant. In fact the curve of coal consumption against percentage of rating, Fig. 2, can scarcely be distinguished from a straight line. The flue gas temperature was 360 deg. at 56 per cent of rating and 400 deg. at 96 per cent: both figures are unusually good, with not much difference between them, certainly not more than would have been offset by the probably excessive air supply at the lower temperature and rating had the boiler had a grate of normal size. The difference between the efficiencies at half load and full load was about 1½ per cent. This means an excess coal consumption at full load of about 0.05 lb. per h.p-hr. Under the most unfavorable conditions, continuous service, the boiler running at full load would waste about $^1/_5$ ton of coal per year per horsepower capacity. To offset this waste it would be necessary to duplicate boiler, piping, smoke flue, etc., at an initial cost of perhaps $20 per h.p. The saving of $^1/_5$ ton of coal per year, which is the maximum possible, would usually not pay fixed charges on an investment of $20.

William Kent. Fig. 2 confirms what has been generally found, that there is a slight decrease in efficiency with increased rate of driving of the boiler, and that decrease will be less the more the theoretical ratio of air approaches the combustible. If air supply is excessive the efficiency will fall off much more rapidly than is shown in Fig. 2. The reason why the maximum efficiency is shown at such a low rate of driving is undoubtedly due to the fact that this boiler was thoroughly covered with non-conducting material and the loss by radiation was extremely slight.

Professor Ennis has spoken of the rate of combustion and the ratio of heating to grate surface. Probably 15 years ago, at a meeting of this Society, in discussing a paper by W. W. Christie, the writer showed that there was no change in efficiency necessarily due to a change in the rate of combustion, between 5 lb. and 240 lb. per sq. ft. of grate surface per hour, except the loss due to sparks and cinders blown into the stack at the higher rate of driving. There is no necessary relation either between the rate of combustion and the excess air supply over that theoretically required; that is, with a rate of combustion as low as 5 lb. per sq. ft. of grate surface per hour, perfect combustion is possible with a certain small excess air supply, and at 20 times this rate without any greater percentage of excess air. The two variables are the thickness of fire and the amount of draft, both of which are under control of the fireman, and excellent results are also attainable with a high rate of combustion, provided the grate surface is small enough, and the draft and thickness of fire regulated to get the proper analysis of the gases. If there is about 3 per cent of oxygen in the waste gases, and in the case of a coal-burning furnace, an even fire, there will not be more than one-half of 1 per cent of CO, and that condition will give the maximum boiler efficiency, provided the baffles are properly arranged and there are no leaks of air or other troubles, and the boiler is not being driven beyond its most economical rate.

J. H. Browne said that the method of baffling this boiler was somewhat new. He had seen trials with a similar method of baffling, but the experiments were not continued long enough to be conclusive. It seemed to him that although the method of developing a baffling material was interesting, the creeping of the tubes would break up the material, and he asked if the author had data on this.

The interesting fact was shown that the best economy was at from 50 to 60 per cent of the boiler rating, possibly accounted for by the superior installation of the boiler. In view of the fact that the ratio of 56 per cent appeared to be the best, this large boiler had at least one advantage from a commercial standpoint. Anyone who had to do with boiler-room operation no doubt knew that the average fireman liked to run about twice as many boilers as necessary. With a plant designed so that it would run at best efficiency at 56 per cent, this matter had been helped. On the other hand, a good deal more money was invested for the same size boiler under these conditions.

D. S. Jacobus. Mr. Kent has said that the percentage of oxygen in the flue gases might to advantage be made lower than is indicated by the tests. An important feature of the analyses is that they nearly all show some carbon monoxides. The determination of carbon monoxide in boiler tests is often subject to considerable error. In the present instance the analyses were undoubtedly correct, and the limitations in efficiency through striving to run with but little excess air, or a low percentage of oxygen in the flue gases, is clearly brought out.

On decreasing the amount of excess air there is a tendency to approach a zone where carbon monoxide will appear in the flue gases. The better the furnace the higher the percentage of carbon dioxide will be before the carbon monoxide appears. In endeavoring to obtain high efficiencies, we take great care to watch for carbon monoxide. It is often an easy matter to get, say, 10 or 11 per cent of carbon dioxide with little or no carbon monoxide, but after exceeding 13 per cent of carbon dioxide the furnace must be exceptionally good to consume all of the carbon monoxide.

Measuring the furnace temperatures has been suggested. It is extremely difficult, if not impossible, to do with accuracy, as the effect of the radiant heat complicates matters. A long time ago I calibrated a Uehling-Steinbart pyrometer, and great difficulty was experienced in obtaining comparative temperatures.

In an ordinary furnace the temperature of the gases may be different from the temperature due to the radiant heat and on this account there are variations depending on the form of the end of the pyrometer which is exposed to the conducted and the radiant heat. The arrangement of the water heating surface with respect to the furnace also affects the temperature measurements, and the same applies in a lesser degree to temperature determinations of the gases at different points within the setting.

C. D. Young. In some recent work with superheater locomotives we have found that generally the superheat will increase with increased evaporation or increased burning rate of the boiler. This is confirmed in stationary practice, I see, by the conclusions drawn in Par. 21. The diagram which illustrated this, however, has the line curved in the upper right hand corner, whereas our tests with a superheater applied to water tube locomotive boiler seem to indicate that the line should be straight; that is, the increase in superheat is almost directly proportional to the increase in the burning rate.

A question which we have before us just now in locomotive practice is the determination of the effectiveness of water and superheating heating surface in a boiler and I would like to know if Mr. Bump has data to show what the heat transference rates are as between the flue gases and the water and the flue gases and the steam. Our results seem to indicate that the superheater heating surface *per se* is only about half as effective as the water heating surface in heat transfer.

The Author. Professor Ennis has made the statement that "as large a heating surface as was provided should have more completely absorbed the furnace heat." I would call his attention to the last two columns of Table 3 which show that there was very little difference between the temperatures of the gases leaving the boiler and the saturated steam in the boiler. The temperature of the fluid within the tubes is the minimum limit of the exit gas temperature, and no amount of heating surface will reduce this limit.

The difference between the efficiencies at half load and full load was more than 3 per cent, not about 1½ per cent as Professor Ennis has stated. This means that the boiler running at full load would waste 0.5 tons of coal per horsepower-year, instead of the 1/5 ton stated in the discussion.

Although there is fuel economy in running at half load, yet fuel economy is not all there is to the cost of steam.

These tests are not put forward to show that the cheapest steam is to be obtained at low boiler rating. This would only be true with a very high priced fuel. With the usual prices of coal, and interest and depreciation taken into account, this boiler would need to run at 150 per cent rating at least, in order to generate steam at the lowest cost.

In reply to Mr. Young relative to the superheat curve of Fig. 2, the points obtained by these tests as well as from a later series of tests made after the baffles had been removed indicate that the line should be a curve, not a straight line. In other words, the superheat did not increase so fast as the boiler rating. The fact that the superheater was too small for the quantity of steam generated at the highest ratings may have had some influence upon the superheat.

In regard to the relative rates of heat transfer in the superheater and in the boiler, we have no data that will give an absolute measure of this transfer, but can get an approximate comparison from the drop in temperature of the gases as they pass over the several surfaces. Making calculations on this basis, we find that the rate of heat transfer for the superheater is fully as great as for the adjacent portions of the boiler tubing.

AXIOMS CONCERNING MANUFACTURING COSTS

BY HENRY R. TOWNE, PUBLISHED IN THE JOURNAL FOR DECEMBER 1912

BRIEF

In a paper entitled The Enginner as an Economist, contained in Volume 7 of the Transactions, 1886, by the present writer, is the following statement:

"To insure the best results, the organization of productive labor must be directed and controlled by persons having not only good executive ability, and possessing the practical familiarity of a mechanic or engineer with the goods produced and the processes employed, but having also, and equally, a practical knowledge of how to observe, record, analyze and compare essential facts in relation to wages, supplies, expense accounts, and all else that enters into or affects the economy of production and the cost of the product."

The following paper attempts to sum up the results of modern experience in these matters, and to state the views now generally held concerning the fundamental principles which underlie industrial accounting. The conclusions reached are embodied in the Axioms; the arguments on which the latter are based are contained in the intermediate text.

DISCUSSION

ARTHUR C. JACKSON. I wish to point out a different procedure from the one suggested by the author in Axiom 9. If the interpretation of the author's statements and the arguments I wish to present for consideration can be accepted, a somewhat different result than that which has in the past been generally acknowledged correct will have to be considered.

If in Par. 12, " production and selling are two separate and distinct processes " (and I would be willing to differentiate still more decidedly between them and call them separate and distinct functions), is there any reason for distributing commercial expense upon the bases of shop costs?

The statement in Par. 11 advocating the elimination of material

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from the basis of distribution of non-productive or manufacturing expense on account of its varying value should lead to the elimination of this variable component from the basis of distribution of commercial or selling expenses. This leaves only two bases upon which commercial or selling expenses may be distributed, productive labor or selling prices.

Inasmuch as "producing and selling are two separate and distinct processes," does it not appear that the total selling expense should be distributed upon the basis of sales, just as the total of all expenditures incident to, and not an element of, the production or the product, are distributed upon the basis of productive labor?

Is it not often the case that the selling price of the manufactured product remains more uniform than the prices of the materials entering into its manufacture; and that the selling price is much more affected by market and trade conditions than by variations in factory costs?

It is always the ideal of the efficient works manager to get out an ever increasing production with an improvement in quality and a reduction in costs. Likewise it is the object of every sales manager constantly to increase the volume of sales, increase the profit and reduce the proportionate selling expense.

Is not, therefore, the total value of sales the proper basis for the distribution for commercial or selling expenses? This is where the principle that an article can have but one cost fails and so may my argument, but I submit it for consideration because I believe it to be convenient, especially where we have to compete in export markets with foreign competition at a lower price.

If my mthod of determining cost by basing commercial or selling expense upon the sales instead of upon the manufacturing cost could be accepted and used it might result in less oppression of the American manufacturer by the departments of justice and internal revenue and tariff boards, as we could then *show* that goods sold in export markets at a price below the domestic actually have a lower cost than goods sold in the domestic markets at a higher price.

Augustus Smith. The title of Mr. Towne's paper, Axioms Concerning Manufacturing Costs, does not at once suggest the full scope of the paper. We want to know the final or "actual cost," as Mr. Towne puts it, to know what to charge for our

CORNELL UNIVERSITY

On February 18, George A. Orrok, Mem. Am. Soc. M. E., spoke to the Sibley College Student Branch on the subject of The Development of the Power Plant. The entire senior class attended the meeting.

LEHIGH UNIVERSITY

The Mechanical Engineering Society of Lehigh University was entertained on the evening of February 25 at the home of Dr. Drinker, President of the university. J. H. Sheppard (1913) read a paper on the Modern Tendencies in Marine Propulsion, in which he discussed the various systems of marine propulsion in present use and their future. Dyer Smith of New York then gave an address on Patent Experting.

PENNSYLVANIA STATE COLLEGE

K. C. Grant of Pittsburgh, Pa., addressed the meeting of the student section of Pennsylvania State College on February 7, upon The Conservation of Water Supply and Power, with special reference to its European aspects.

On February 21, a lecture on Cork and its Uses was given by Mr. Prentice of the Armstrong Cork Company of Pittsburgh. This was illustrated by lantern slides and showed the production, manufacture and application of cork.

PURDUE UNIVERSITY

Prof. C. B. Veal, Mem. Am. Soc. M. E., addressed the student section of Purdue University on February 25, his subject being The Progress of Aviation from an engineering standpoint.

STEVENS INSTITUTE OF TECHNOLOGY

At a meeting of the Stevens Engineering Society on February 11, Rudolph Hering, Mem. Am. Soc. M. E., addressed the members on Sewage Disposal. J. H. VanderVeer discussed the subject at the conclusion of the address.

Dayton C. Miller gave an interesting lecture before the society on February 18, on Sound Waves and How to Analyze them.

On February 28, E. H. Peabody of the Babcock and Wilcox Company, New York, spoke upon Marine Boilers at a meeting of the organization.

On March 4, the Hell Gate Bridge and the New York Connecting Railway, was presented by Henry Hornbostel; and on March 10, a paper on Leather was read by Allen Rogers.

The following officers were elected on March 11: L. F. Bayer, president; R. Trowbridge, vice-president; C. H. Colvin, secretary; S. S. Parsons, treasurer; L. E. Saxby, assistant secretary.

UNIVERSITY OF CINCINNATI

On February 19, A. J. Baker of the Cincinnati Milling Machine Company addressed the University of Cincinnati Student Section on The Engineer's Relation to the Sales Department in a Modern University. He described the methods and the manner of analysis used by the sales engineer in making estimates on time required to do work with machines, jigs and special tools, and exhibited lantern slides showing some of the results obtained.

UNIVERSITY OF ILLINOIS

On February 15 the annual smoker of the Student Branch at the University of Illinois was held at Hessel Hall, and was perhaps the most successful smoker ever held by the society. About two hundred were in attendance. An unusual number of good speeches were made by different members of the faculty. Prof. C. R. Richards closed the meeting by a talk on the future of the mechanical engineering course, outlining carefully the plans of the department concerning its growth and ideals. He congratulated those present on their wise choice of a profession, and urged each one to interest those who had a tendency toward engineering to take such a course.

Prof. E. C. Schmidt, Mem. Am. Soc. M. E., lectured on The Locomotive as a Power Plant on February 21. The general theme of this talk brought out the marvelous efficiency of the locomotive in view of the fact of the intensity of operation, and figures were also shown relative to the efficiency of the locomotive and that of the power plant. A general discussion followed.

UNIVERSITY OF MISSOURI

A very interesting discussion of Modern Machine Shop Methods was given at the March 3 meeting of the University of Missouri Student Branch, by Irwin Dunbar (Student 1911) and F. I. Kemp (Student 1911).

UNIVERSITY OF NEBRASKA

Railroad Shop Organization was the subject of a paper presented by W. O. Forman, head mechanical engineer of the Havelock Shops, C. B. & Q. R. R., at a meeting of the University of Nebraska Student Branch on March 4.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The list of "men available" is made up from members of the Sociey. Further information will be sent upon application.

POSITIONS AVAILABLE

325 Young engineering graduate, mechanical or electrical engineer, for sales work in New York office.

330 Sales manager for concern manufacturing steam turbines and centrifugal pumps. Location New York. Apply through the Society.

332 Competent engineer, experience in sanitary and hydraulic lines, with initiative, good presence and ability to reason from cause to effect. Location New York. Salary $2000 to $2400 a year.

333 Instructor in theoretical work in electrical engineering; candidate must be a graduate of a leading engineering school and have experience in teaching, with considerable practical experience in electrical engineering. Salary about $1400 to start. Address Dean Calvin H. Crouch, University of North Dakota, Grand Forks, N. D.

334 Two young engineers with technical training as mechanical and electrical engineers, preferably one or two years' experience, for concern in Mexico in large plant for cyaniding ores. Positions would lead to assistant superintendency. Salary $200 Mexican currency per month and transportation down.

337 Mechanical draftsman experienced in design of large steam or gas engines. Only first class men need apply. Location Ohio. Apply through the Society.

339 Young engineer to take charge of purchasing and cost departments of established concern manufacturing ball bearings. Location Connecticut.

342 Operating engineer as assistant in engine room, boiler and pipefitting shop. Good opportunity. Location Connecticut.

343 Efficiency man, assistant in department of textile manufacturing concern. Location Connecticut.

345 Engineer, technical graduate, capable of going into field acquiring data and preparing designs for furnaces, machinery, mill construction and power-plant work, piping, etc. Salary to start $100. Location New Jersey.

347 Young engineer, with three to five years' experience in operation

of boiler plants wanted for Boston firm of consulting engineers. Man preferred who has been connected with the operation of boiler plants and utilization of steam in mills. Technical education desirable but not essential. Apply through the Society.

348 Steam engineer for power-house equipment. For one competent to take entire charge of power-plant operation and repairs, salary $150. Location Maryland.

349 Connecticut concern, desires three architectural draftsmen familiar with factory construction and manufacturing. Salary $20 to $40 a week.

350 Ohio concern, desires two draftsmen, a detailer and designer, on machine tools.

353 An old established house, branching into new line of work, desires services of recent technical graduate in mechanical or electrical engineering, preferably of one or two years' experience, to enter into contract for a term of years for service in the tropics. Must be of exceptional habits, in best health, able and active. Apply through the Society.

354 Head of mechanical department of large cloth finishing plant, to have charge of machine shops, carpenter and yard work, trucking, up-keep of machines and building, new work and repairs, electrical distribution. Position is practically master mechanic's, but would need good executive ability.

356 Instructor in mechanical engineering wanted by an eastern university; one with practical and teaching experience preferred; salary $1000 to $1200. Apply through the Society, giving details of training and experience and references.

MEN AVAILABLE

58 Member, experienced in the design and manufacture of pumping machinery would like to correspond with parties now building steam pumps who are about to take up centrifugal lines.

59 Mechanical engineer, desires position as works manager or assistant to superintendent; age 29, college training; five years' practical experience, holding positions as foreman of power plant repairs, erecting foreman, sales engineer and contractor. At present with large locomotive works.

60 Executive engineer desires position as superintendent or works manager, technical graduate with practical shop training and experience in organizing and handling men. At present assistant to general superintendent of works employing 6500 men.

61 Member, 34 years of age, desires position as works engineer; 15 years' experience in power plant design, construction and supervision piping, heating, mill engineering. At present head of engineering department of large plant, but desires change of location.

62 Technical graduate, age 37, practical mechanic with ten years' experience in executive capacity, mill engineering, power generation, transmission, etc., desires position as factory engineer or works manager with progressive concern in New England.

63 Assistant to purchasing agent; experienced in materials, miscel-

laneous machinery and matters pertaining to construction, contracts, specifications, general mechanical and electrical engineering.

64 Plant engineer, maintenance, inspection and construction departments, government, railroad and factory experience or as general engineering assistant.

65 Member, age 34, technical education, executive ability, experienced in design and installation of machinery, coal-handling plants, and with broad experience in the design and fabrication of all classes of structural steel and plate work, would be pleased to communicate with firm desiring to secure the services of a reliable hustler to take charge of work.

66 Mechanical engineer, graduate Stevens Institute of Technology, experienced in plant superintendence and construction, gas and steam engineering, boiler design, manufacture and sales, acquainted with territory in vicinity of New York City.

67 Young technical graduate employed as materials testing engineer, desires change of position and location, central or western states preferred.

68 Member, mechanical engineer and expert machinist, with ten years' experience in industrial and vocational education, desires executive position along that line. Can furnish best of references.

69 Sales manager, exceptional experience in design and selling boilers, engines and complete power plants, construction and installation. Specially good at getting results from branch offices and salesmen. Valuable acquaintance gained by 15 years' successful selling in territory east of and including Pittsburgh and Buffalo; both practical and technical training.

70 Contracting sales engineer for structural steel company. Junior member. Six years' general experience in steel business as draftsman, estimator and engineer. At present employed; for the past two years as contracting engineer for plate and structural shop, desires advantageous change. Confidential, apply through Society.

71 Technical graduate, 26 years of age, experienced in shop, teaching applied mathematics, experimental mechanics and engineering physics, 15 years in engineering and contracting, covering refrigeration, water supply, power and lighting plants including machinery and buildings, testing process development and consulting work over a wide range of subjects. At present acting professor of engineering practice in a prominent engineering school. Has no family and would like to find something to do in the Orient or south of the equator.

72 Mechanical engineer with splendid practical shop and commercial experience, expert in the up-to-date manufacture of interchangeable machinery and parts, resourceful in design and methods for reducing costs and increasing production, good organizer and system man with excellent executive ability. At present engaged, but for good reasons desires change. Splendid record and references.

73 Member, technical graduate, 12 years' experience designing and estimating, four years' field and shop experience, with working knowledge of electricity, is open for position. Outside construction or contracting work preferred. Excellent references.

74 Assistant professor desires change. Now in charge of a department in an eastern technical school. Best of reasons for change. Will consider openings for assistant professor or better grade in mechanical engineering; experienced in steam, hydraulic, gas engine, strength of materials, and cement laboratories and mechanical engineering subjects. Practical experience in consulting and testing engineering work. Best of references. Apply through the Society.

75 High-grade efficiency engineer desires change.

76 Junior, age 30, technical graduate experienced in the design, construction, operation and maintenance of power plants and sub-stations, testing electrical machinery, desires position of responsibility with hydroelectric company or with contractors doing power plant or hydroelectric work. Best references. $150-200 per month. At present employed.

77 Manager or engineer capable of taking charge of sales department, advertising and correspondence or shop.

78 Junior, graduate mechanical engineer, ten years' experience as superintendent construction; master mechanic in large factory; past three years with beet sugar company in charge of designing, constructing and operating numerous pumping plants, irrigation systems, pipe and power lines, accustomed to figuring cost and purchasing materials. Executive ability and excellent references; desires to make change about May 1.

79 Young engineer, technical training; five years' machine tool shop experience in various departments, desires to locate with engineering firm.

80 Junior member, experienced mechanical rubber goods superintendent and factory manager desires position in factory in the East.

81 Member, age 34, technical and practical training, desires position in vicinity of New York preferably, with mechanical or marine engineering concern; experienced in the design, construction and operation of stationary, marine, and submarine machinery, and special automatic and hydraulic machinery. Good draftsman and designer, licensed stationary and marine engineer. Past five years executive engineer in charge of industrial plants. At present employed. Excellent references. Salary according to position.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

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W. H. Blauvelt
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Carl Thomas
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On Arrangements Leipzig Meeting 1913

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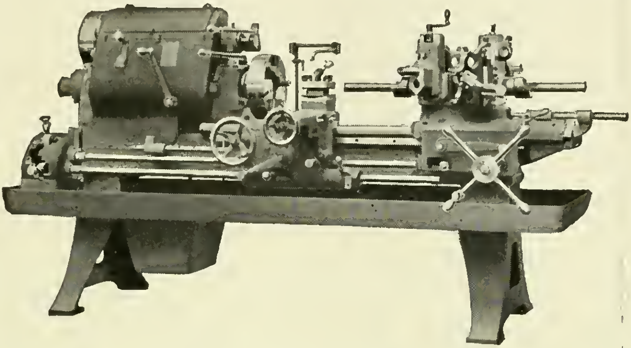

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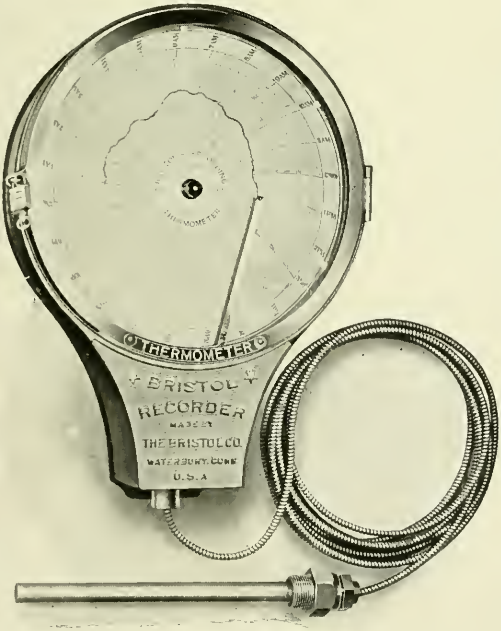

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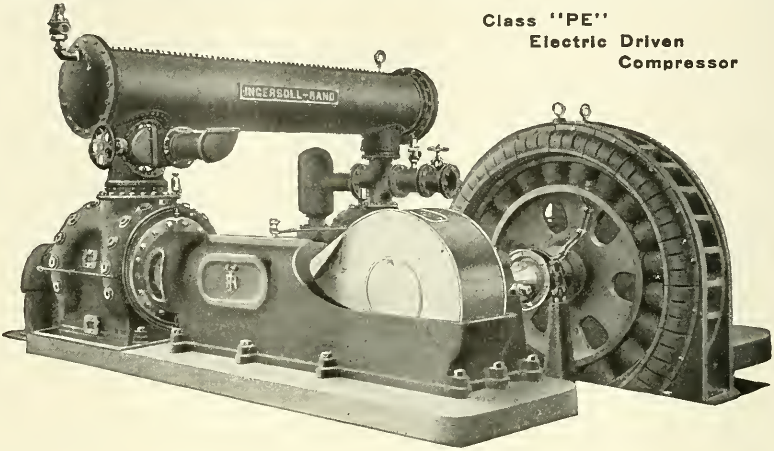

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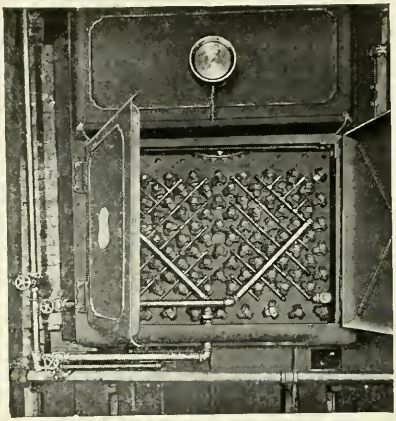

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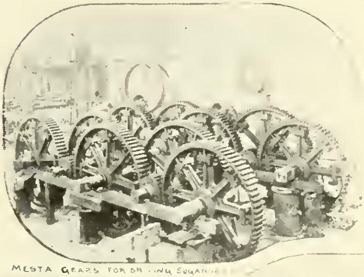

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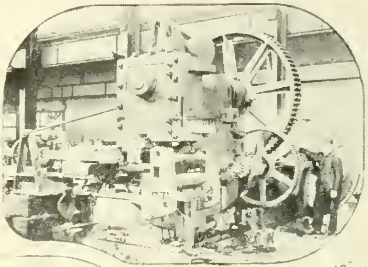

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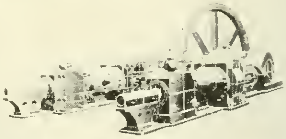

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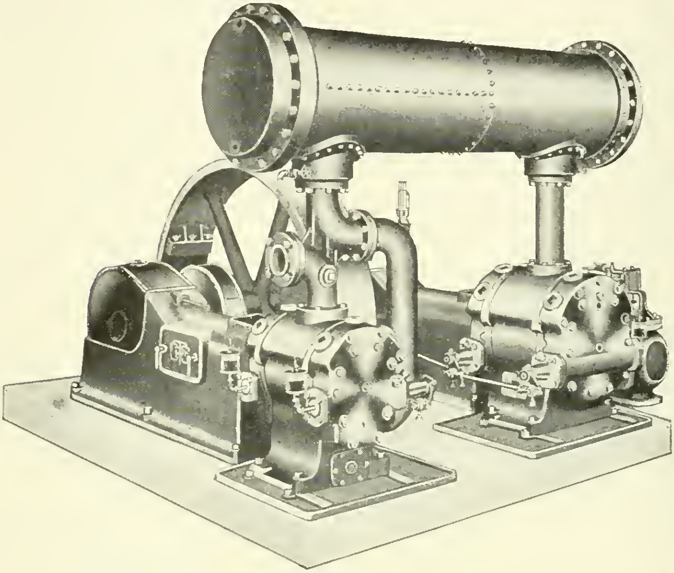

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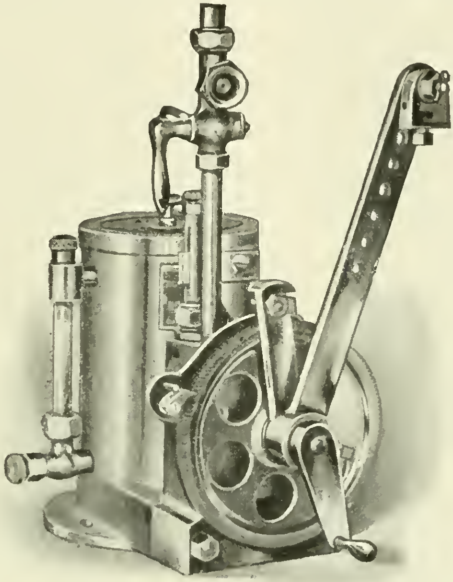

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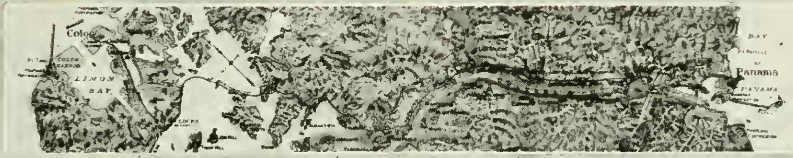

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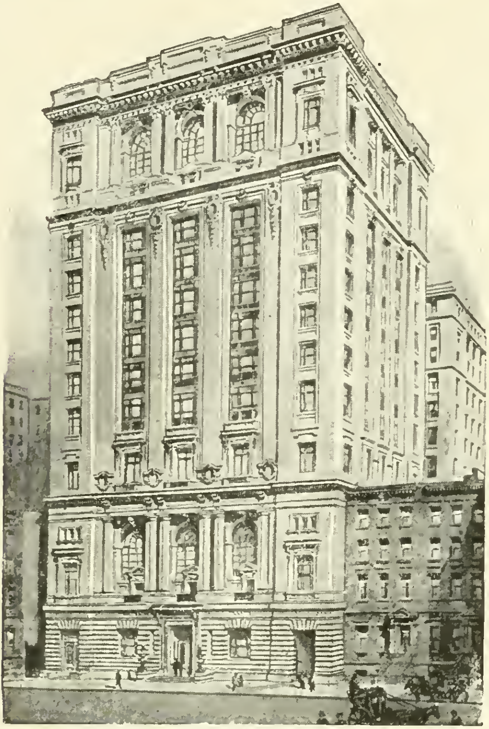

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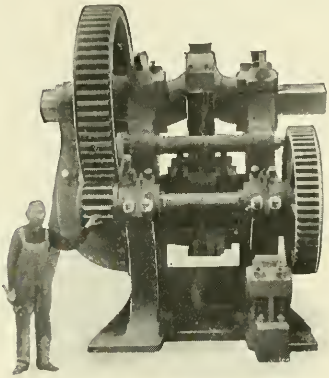

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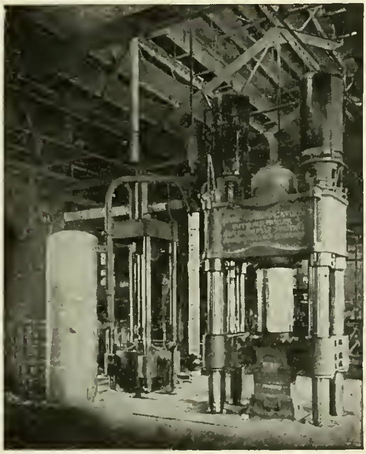

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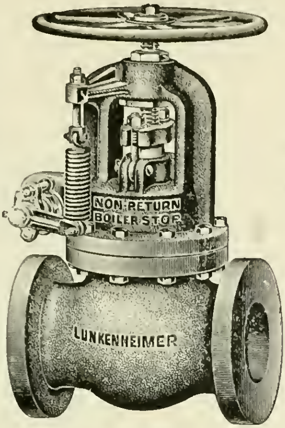

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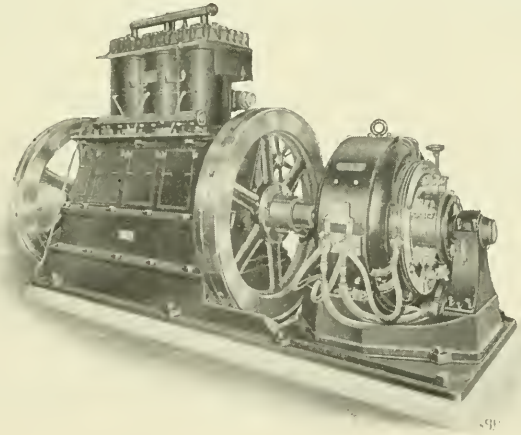

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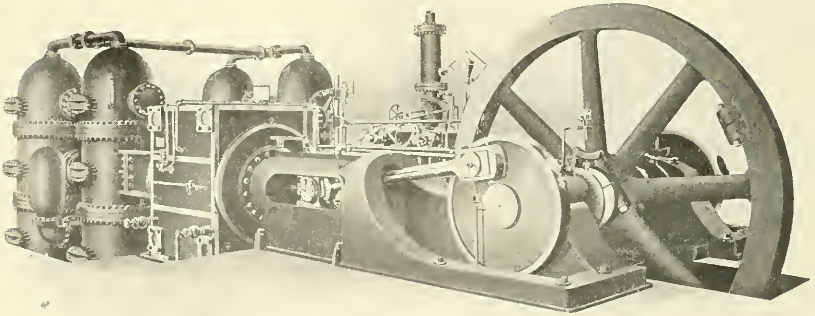

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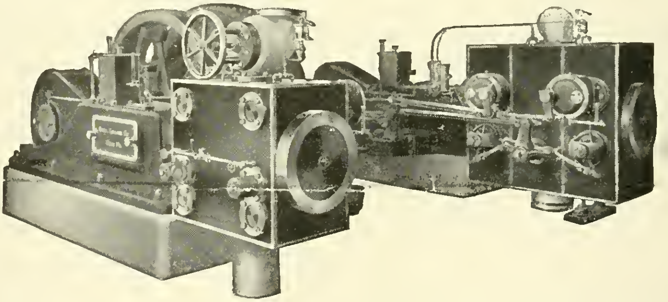

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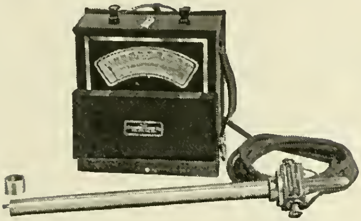

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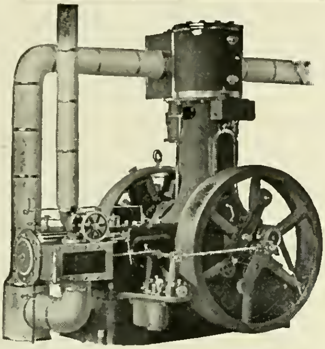

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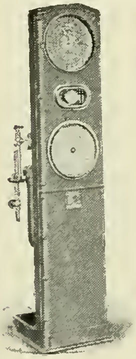

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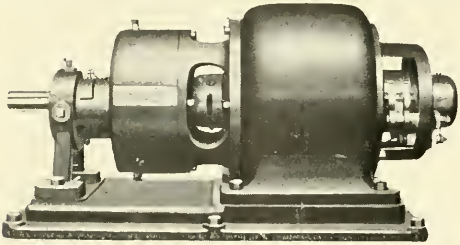

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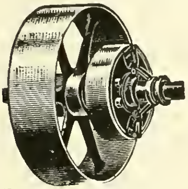

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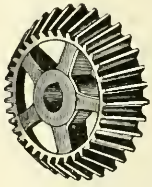

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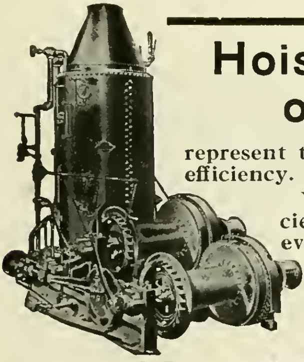

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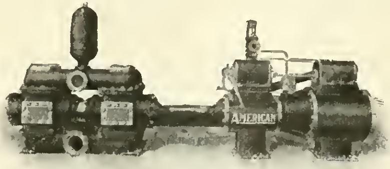

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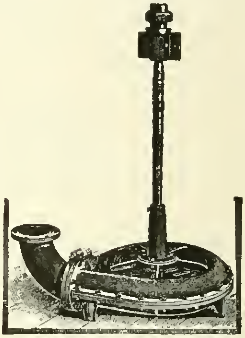

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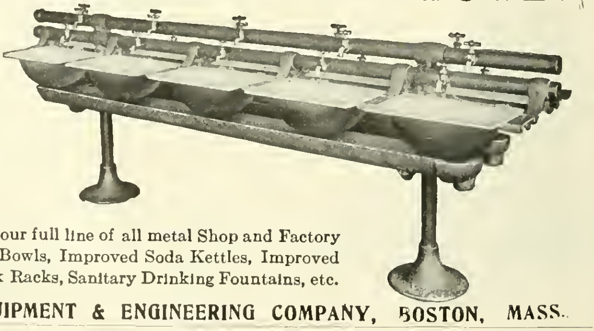

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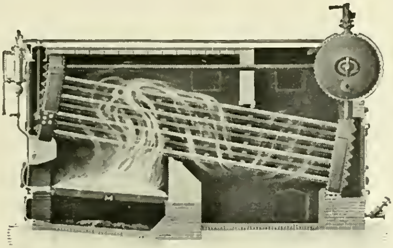

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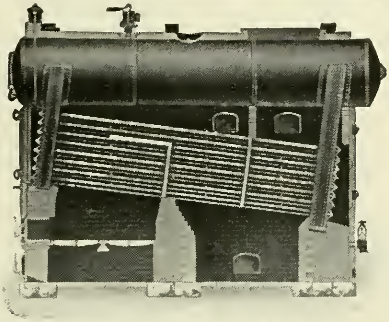

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